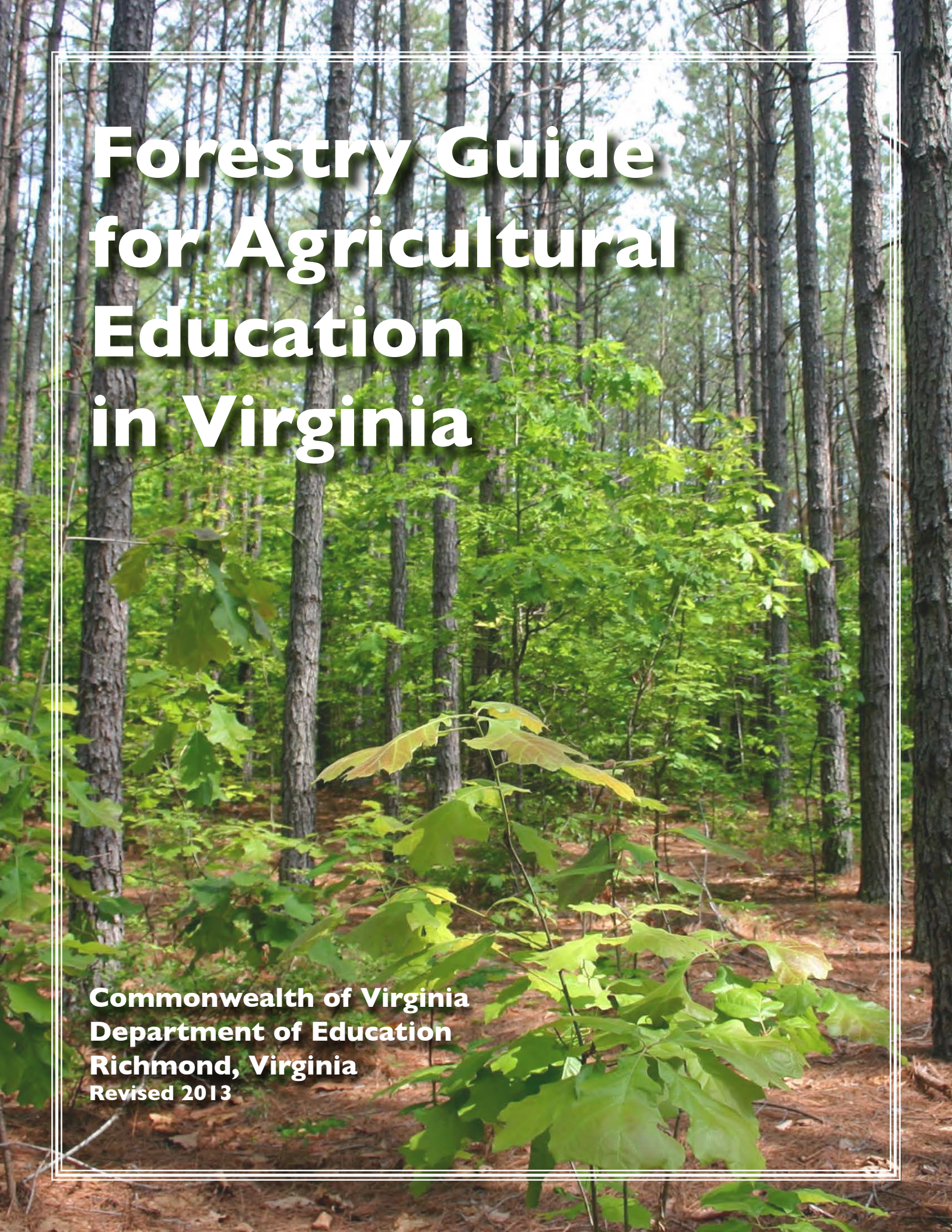

Forestry Guide for Agricultural Education in Virginia

Commonwealth of Virginia
Department of Education
Richmond, Virginia
Revised 2013

Edited and produced by
CTE Resource Center
Margaret L. Watson, Administrative Coordinator
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The Center is a grant project of the Virginia Department of Education, Office of Career and Technical Education Services, and is administered by Henrico County Public Schools, Office of Technical and Continuing Education.

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Acknowledgments

This publication is an updated and revised edition of the 2002 Forestry in Agricultural Education in Virginia and presents to the teacher lesson plans that may be used in conjunction with agricultural education courses. Teachers may use the lesson plans in their entirety or in part, and information may be duplicated for students. A teacher's notes page has been added to the end of each lesson so that the teacher can personalize the lesson plan to his/her own teaching.

The following are recognized for their efforts in 2012 toward the completion of this new edition of the guide:

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EQUIPMENT, SUPPLIES, AND MATERIALS

- Document camera
- Interactive whiteboard

The Contribution of Forest Enterprises to Virginia

TEACHER: _____

SCHOOL: _____

GRADE LEVEL: 9–12

TASKS/COMPETENCIES

- Locate markets for forest products.
- Explain how urban forests fit into an urban ecosystem.
- Identify the benefits of Virginia's forests.

OBJECTIVES AND GOALS

- The student should be able to define the term *forestry*.
- The student should be able to describe the composition of Virginia forests and their ownership.
- The student should be able to identify trends of change in Virginia forests.
- The student should be able to determine the economic importance of forestry enterprises to Virginia.
- The student should be able to list products and benefits obtained from forestlands.
- The student should be able to predict future trends in forest production in Virginia.
- The student should be able to define the term *urban forest.*
- The student should be able to define the term *agroforestry.*

Lesson

1

ACTIVITIES

► Preparation

Lesson Approach

Display a map of Virginia fores lands in the classroom. Ask students to compare the map with a road map of Virginia that shows cities and highways and describe where forests occur. Ask: What types of forest lands are most prevalent in Virginia? Are they on government lands? Near cities? In which ecological region (i.e., coastal plain, Piedmont) are they most prevalent?

General Situation

Students should read *The Value of Virginia's Forests (*http://www.dof.virginia.gov/print/econ/Value-Of-VAs-Forests.pdf) and list the reasons why forest enterprises are critical to Virginia's economy. Other Virginia Department of Forestry resources can be found at http://dof.virginia.gov/print/index.htm.

► Application

What is forestry?

Forestry is the art, science, and business of managing forestland.

What is urban forestry?

Urban forestry is the art, science and business of managing forestland in urban areas (towns and cities).

What is agroforestry?

Agroforestry is the term used for producing agricultural and forest products on the same land.

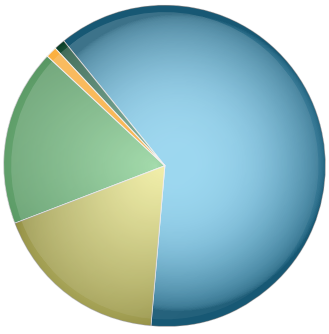
How much land is considered forest in Virginia, and who owns it?

According to the 2013 State of the Forest report produced by the Virginia Department of Forestry, most of the commonwealth's forests are privately owned, a slight increase over the last two decades. Public and corporate ownership makes up about two-thirds of the forestland in Virginia.

Who Owns Virginia's Forests?

Percentage of ownership in 2012:
Individual/Family 67%
National Forest 18%
Corporate 18%
Other public 1%
Forest Industry 1%
Total forestland: 15.9 million acres

Virginia Department of Forestry, 2012



Forest Ownership in Virginia by Percentage			
Ownership	**1992**	**2001**	**2007**
Individual/Family	67	66	66
Public	10	14	17
Corporate	13	13	13
Forest Industry	10	7	4
Total forestland	16 million acres	15.8 million acres	15.76 million acres

Lesson

1

What types of forest are in Virginia?

- 65 percent are hardwood; yellow poplar is the most abundant.
- 19 percent are pine types.
- Pine plantations comprise 44 percent of pine acreage; loblolly pine is the principal planted tree.

How has Virginia forestland changed over the years?

In 1980, 64 percent of the state was forested. In 2001, this increased to 67 percent. Reforestation efforts and forestland management practices have led to this increase. However, by 2009, the amount of forest cover had slipped to 63 percent. Land-use change related to the state's growing population is a major factor in the decline.

What is the economic significance of forestland to Virginia?

Each year, Virginia's forests provide more than $27.5 billion in economic benefits to the commonwealth. These economic benefits include:

- More than $23.4 billion generated by the forest products industry and related activities
- $350 million paid to forest landowners for the harvest of products
- 144,380 jobs in the forest products industry
- Forest-related recreational spending in excess of $2.4 billion

In addition to the direct economic benefits, the extensive cover of forestland in Virginia provides its residents with many valuable ecological services, including:

- Protection of water quality
- Protection of air quality
- Aesthetic quality
- Moderation of climate, including the offsetting of carbon emissions that contribute to global warming
- Provision of habitat for many plant and animal species.

These nonmarket services have been conservatively valued at more than $1.7 billion annually. Forests in Virginia are healthy and diverse, yet they are changing due to population growth and other socio-economic pressures.

The growth of the forest products industry has resulted in a strong economy. A continuing high level of management and protection is needed to maintain this invaluable forest resource now and for future generations.

The importance of forests to our economic health is well-documented. To many landowners, a growing timber crop is money in the bank. Also, landowners need fence posts, lumber for buildings, and other forest products. By growing them on their own land, they can save money.

The forest dollar is new wealth created from a renewable natural resource. It helps support businesses and services, and provides food and shelter for Virginians.

What Benefits Do We Get from Forestland?

Watershed value: We depend upon water every day. Our farms need water for crops and livestock; our homes for cooking, washing, and drinking; our towns and cities for firefighting, sanitation, and recreation; and our industries for manufacturing processes. Virginians consume the equivalent of 60 gallons per person per day.

A well-managed forest provides the best protection for a watershed. The leaves and branches of trees and shrubs break the force of falling rain, and the dead plant material on the ground serves as a big sponge to soak up the rain and release it slowly into the soil beneath. The roots help to anchor the soil, preventing destructive erosion that silts the rivers, lakes, and reservoirs.

Forests help prevent disastrous floods and provide water vital to life.

Improved wildlife habitat: Virginia's forests provide food, cover, and habitat for wildlife. Managed forests that contain a diversity of habitats will encourage and attract many wildlife species. Edges of forests create transition areas between forest types and provide an attractive site for wildlife that use edges of habitats. Fence lines, forest openings, and scalloped forest edges provide corridors for wildlife to move into and through the area.

Recreational value: Increasing population and shorter working hours create more demand for outdoor recreation. Virginia's forests are home to wildlife, which supports a multimillion-dollar industry. Thousands of tourists enjoy Virginia's forest beauty, spending more than $2 billion annually on forest recreation activities. Fishing, boating, and other water enthusiasts spend millions for equipment to use on lakes and streams surrounded by forests.

Ecosystem services: Virginia's forests provide environmental benefits and services, such as carbon storage, biodiversity, pollination, recreation, aesthetics, and reducing nutrient loads to streams and enhancing air quality. These regulating and cultural services are in addition to the traditional wood products our forests provide. Our forests are truly the natural infrastructure on which our quality of life depends.

Forest growth in Virginia annually captures and stores about 6.42 million metric tons of carbon dioxide emissions. Carbon dioxide is considered by many to be a major greenhouse gas. The growth of Virginia's forests offsets about 20 percent of the total annual carbon dioxide emissions in the state (http://www.dof.virginia.gov/ecosys/climate-change.htm). Voluntary markets are emerging to help forest landowners capture a value for this carbon-storage service. However, each year, approximately one million metric tons of carbon dioxide (about 3 percent of emissions in the state annually) is emitted into the atmosphere due to land-use changes, such as the loss of forest cover.

Products from trees: Wood, in its many forms, is an integral part of the American way of life. Thousands of useful items come from trees, from charcoal to medicine. Wood, even in the raw form, has fascinating qualities. It is highly rated as a radiation shield and as an insulator. It is resilient; think of its use as handle stock for pounding tools such as hammers and axes. There is no substitute for the wooden crosstie for railroad construction. Many food flavorings and additives come from trees. Rosin used by musicians and athletes comes from our pines. The finest gunstock material in the world is made from America's black walnut. Wood has beauty, warmth, and strength; it is the favorite material for furniture making.

Interest in non-timber forest products is growing. Examples include edibles such as fruits, nuts, and mushrooms; medicinal and herbal products such as ginseng and goldenseal; and decorative products such as holiday greenery and baskets. Firewood, charcoal, and woody biomass are beneficial products that can come from underutilized species or smaller branches and tops of harvested trees.

Trees also provide energy savings, helping to shade a building or block winter winds. A good tree canopy decreases the overall summer temperature in urban areas.

Sources: http://www.dof.virginia.gov/fia/resources/2009_FIA_VA_Forest-Inventory-Fact-Sheet.pdf
http://www.dof.virginia.gov/print/aboutus/SOF-2009.pdf
http://www.dof.virginia.gov/print/aboutus/SOF-2012.pdf

Area of Forestland, by Ownership Classes		
Ownership Class	**2001 area (thousands of acres)**	**2007 area (thousands of acres)**
National Forest	1,468.1	1,749.5
Other Federal	221.3	531.6
State	211.4	300.2
County and Municipal	82.5	217.2
Forest Industry	1,554.8	551.2
Individual landowner	3,870.4	9,906.7
Other nonindustrial private	7,817.7	2,468.5
Total of All Ownerships	15,447.5	15,724.8

Source: 2007 data: http://www.srs.fs.usda.gov/pubs/rb/rb_srs159.pdf

► *Presentation: The Changing Forest Picture*

History

Forests have played a vital role in making the U.S. a great nation. Native Americans were the first to harvest trees in Virginia, but the use of forest products increased after English settlers landed at Jamestown. Wood products were among the first export goods from the colony, thus laying the foundation for the forest industry so important to Virginia today.

As the U.S. civilization moved west, new uses were developed for the tree and its products. The rapid development from a frontier to our present civilization is partly due to our forest resources. This early period was one of exploitation; the virgin forests were heavily cut and burned. It was a time of land-clearing for agriculture and a time of "cut out and get out" for the wood industry.

This great expansion era created problems for the forests. But forests, although exhaustible, can be renewed. Unlike oil and minerals, timberland can be kept in continuous production; it is not necessary to exhaust an area of forest and move to a new location. The guide will focus on how to restore and manage woodlands properly. The forest is a renewable resource.

The Present Status of Virginia's Forest Resource

Virginia's Major Forest Types in Acres of Commercial Forestland (from forest surveys of 2001 and 2007)		
	2001	**2007**
Pine and Oak-Pine Type	3,352.8	4,763.2
Hardwood Type	12,094.8	10,961.6
Total	15,447.6	15,724.8

Source: 2007 data: http://www.srs.fs.usda.gov/pubs/rb/rb_srs159.pdf

Volume of Timber in Virginia by Forest Surveys		
	2001 (millions of cubic feet)	**2007 (millions of cubic feet)**
Softwood	6,648.4	7,530.2
Hardwood	19,838.4	25,281.9

Source: 2007 data: http://www.srs.fs.usda.gov/pubs/rb/rb_srs159.pdf

Trends in Virginia Forestry

Virginia's population is projected to exceed 10 million by 2030. This growth will have a significant

influence on the forestry resource. The rate of people moving from central cities to surrounding suburbs and exurbs will increase. This will create higher demand for forestland conversion, not only for housing but for business areas, shopping venues, schools, recreational areas, and the other trappings of modern life. The average age of Virginia's population is also increasing. The future population will likely have widely divergent views of what they want from their forestland, and the demand for services from the forest community will have to keep up with the increase in the number of landowners and the increasing diversity in services desired. Virginia is also experiencing increases in racial and ethnic diversity. With this increased diversity will come differing values and cultural beliefs as they relate to forests and forestland.

Besides these special trends, the overall increase in population will increase the demand for forest-related recreational opportunities, expand the need for traditional and nontraditional wood products from Virginia's forests, and almost certainly lead to more clashes over the proper use of forests and what activities should take place in the forests—both private and public.

Most of Virginia's forestland is privately owned. By 2007, ownership of forestland by forest products firms had declined to less than 4 percent of the total. Timber investment management organizations (TIMOs) and real estate investment trusts (REITs) account for much of the forestland divested by forest industry. These two categories of owners continue professional forest management on the properties in their holdings. However, the long-term trend is likely further subdivision and development of these lands.

While current supplies are adequate, the continued loss of forested land may limit supply.

Source: http://www.dof.virginia.gov/print/aboutus/2010-State-Assessment.pdf
The current FIA Web site for Virginia is http://srsfia2.fs.fed.us/states/virginia.shtml

Lesson

1

ADDITIONAL ACTIVITIES

Arrange for students to visit a local forest-related business. Before going, have students compose questions to ask the management about the importance of that business to the local economy. Sample questions include:

- What products are produced by the business?
- Where are the products marketed?
- How much of the raw materials come from the local area?
- How many people are employed by the business?
- What are some of the job skills the business expects from employees?
- How much does the business gross in sales each year?

SUGGESTIONS FOR STUDENT EVALUATION

- Draw a pie graph to illustrate ownership of the 15.8 million acres of forestland in Virginia.
- Which type of forest is dominant in Virginia?
- Is more of Virginia forested now than in 2001?
- Explain the economic significance of forests to Virginia.
- List three benefits from forests that are not economic benefits.

Lesson

1

TEACHER NOTES

Lesson

2

SOL CORRELATIONS

Biology
BIO.1
BIO.3
BIO.4
BIO.5

EQUIPMENT, SUPPLIES, AND MATERIALS

- Cross-section of tree trunk
- Diagram of a tree
- Bulletin board materials
- Increment borer

Understanding How Trees Grow

TEACHER: _____

SCHOOL: _____

GRADE LEVEL: 9–12

TASKS/COMPETENCIES

- Describe basic tree structure and growth.
- Describe the process of photosynthesis.

OBJECTIVES AND GOALS

- The student should be able to name the three main parts of a tree.
- The student should be able to define the term *transpiration*.
- The student should be able to explain how a tree forms annual rings.
- The student should be able to state the difference between terminal buds and lateral buds.
- The student should be able to explain why leaves change color in the fall.

Lesson

2

ACTIVITIES

► Preparation

Lesson Approach

Trees are necessary for our very existence. This lesson will focus on tree anatomy and growth. The following questions may be used to determine a student's knowledge of tree growth:

- What are the parts of a tree?
- How does a tree increase in height?
- How does a tree increase in diameter?
- Why do leaves change color in the fall?

General Situation

Students should discuss these questions/answers:

- Why are trees important to us, other than for the products they furnish? (They hold the soil, increase its fertility, moderate temperature, and create beauty.)
- Why is it important to understand how a tree grows? (A crop cannot be properly managed and grown unless its growth requirements are understood.)

► Application

Have students participate in the following activities:

- Determine the age of trees cut by making annual ring counts on logs by looking at the bottom and top cut, if they have access to logs prepared for loading.
- Determing the age of trees cut by making annual ring counts on portions of logs in the classroom.
- Determine the average height growth of a tree by counting rings on the bottom end and then the number of rings at each cut on the top end of the trunk. The difference in ring counts between any two points, divided into the distance between these points, will give the average height growth per year.
- Example:

Number of rings at stump	25
(minus)	
Number of rings at 5 feet	22
	= 3

5 ÷ 3 = 1.66 feet average growth per year

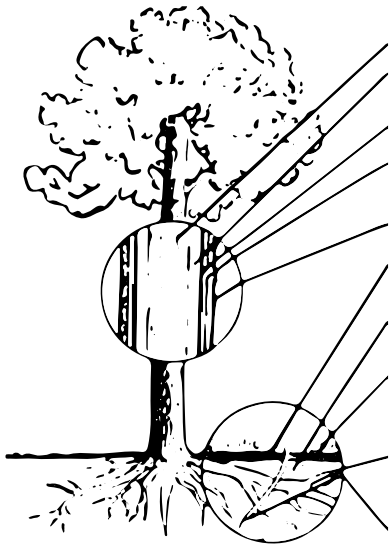
- Use an increment borer to determine the age and growth per year. Bore the tree at 4½ feet from the ground (diameter at breast height), count the rings, and add 4 to determine the age of the tree. (This is necessary since it probably took the tree four years to reach this height.)
- Count 10 rings in from the bark edge and measure the width of the wood making up these 10 rings. This is the radial growth. To determine the *diameter* growth over the last ten-year period, double this figure.
- Example:
  10 rings measure 1½ inches
  2 x 1½ = 3 inches diameter growth in 10 years

Lesson

2

► *Presentation: What is a Tree?*

A tree is a woody plant having one well-defined, erect perennial stem and a more or less definitely formed crown, attaining a diameter of at least 3 inches and usually attaining a height of at least 12 feet. Follow the chart below during the explanation of the parts of a tree and their functions.



Heartwood (inactive) gives strength.
Sapwood (xylem) carries water and nutrients up the stem.
Cambium is where the diameter growth occurs.
Inner bark (phloem) carries manufactured food from leaves to branches, trunk, and roots.
Outer bark provides protection.
Natural mulch of leaves protects surface against drying and erosion.
Decomposing layer (humus) is inhabited by beneficial insects, bacteria, and fungi.
Enriched soil layer is the source of much of the tree's food; it is the home of earthworms, which leave channels for water and air.
Subsoil contains soil particles and parent material. Deep roots find their home here and absorb water and anchor the tree.
Passages through the soil are constructed by insects.

Three main parts of a tree

Roots: The roots of a tree have three main functions:

- They anchor the tree.
- They absorb water and dissolved nutrients.
- They protect against erosion.

Trunk: The trunk supports the crown and produces useful wood. The trunk is made up of the following:

- The *outer bark* protects the tree from injuries and heat or cold, just as skin protects the human body.
- The *inner bark* (phloem) carries foods manufactured in the leaves to the branches, trunk, and roots.
- The *cambium* consists of a layer of cells where growth in diameter occurs. It forms annual rings of new wood (xylem) inside and new inner bark (phloem) outside.
- The *sapwood* (xylem) carries water and nutrients from roots to leaves.
- The *heartwood* was once sapwood but is inactive. It gives mechanical strength to the tree.
- The *annual rings* are made up of springwood and summerwood.

Crown: The crown is the leaf area of the tree, including the branches, which supports the leaves. Size and shape are affected by environment and genetics.

Leaves are the most important chemical factories in the world. Their manufacturing process is called *photosynthesis*. Without this process, there would be no food for people or animals, no wood for shelter, no humus for the soil, no coal for fuel. Every living thing depends on this process.

Photosynthesis (from *photo*, meaning light, and *synthesis*, meaning putting together)

- Inside each leaf, millions of green-colored, microscopic chloroplasts manufacture sugar. They trap radiant energy from sunlight for power. Their raw materials are carbon dioxide from the air and water from the soil. Oxygen, a byproduct, is released. This fundamental energy-storing, sugar-making process is called photosynthesis.
- The chemical formula is: chlorophyll + CO_2 + H_2O + sunlight = $C_6H_{12}O_6$ + O_2.
- What happens to this leaf-made sugar in a tree? With the aid of enzymes, every living cell, from root tips to crown top, goes to work on the sugar. New products result. Each enzyme

does a certain job, working with split-second timing and in harmony with the others. In general, enzymes break down sugar and recombine it with nitrogen and minerals to form other substances.

Enzymes change some sugar to other foods, such as starches, fats, oils, and proteins, which help form fruits, nuts, and seeds.

Enzymes also convert some sugar to cell-wall substances, such as cellulose, wood, and bark, and make some of the sugar into other substances that find special uses in industry. Some of these are rosin and turpentine from Southern pines; syrup from maples; chewing gum from chicle trees and spruces; and tannin from hemlocks, oaks, and chestnuts.

Transpiration is the release of water vapor from living plants. Most of it occurs through the pores (stomates) on the underside of the leaves. Air also passes in and out. Factors that affect transpiration are relative humidity, temperature, sunlight, wind, available water, and atmospheric pressure.

Branches anchor and conduct fluids to the tree's leaves and flowers.

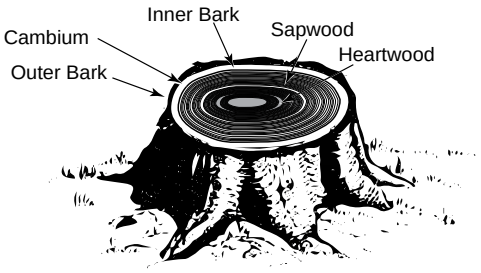
Flowers function as the reproductive organs of a tree.

How does a tree grow?

Diameter growth

The diameter of a tree increases as the vascular cambium layer forms new wood cells on the inside and bark cells on the outside. Alternate growth of spring and summerwood forms annual rings. The cambium is a single layer of cells that retains the capacity to divide throughout the life of the tree.

- Vascular cambium becomes both wood and inner bark. Outer bark is formed by a specialized layer outside the phloem called the cork cambium.
- When the cambium becomes active in the spring, it begins to split off rows of wood cells to the inside and rows of phloem cells to the outside.
- Wood formed in the spring consists of light-colored, thin-walled cells; later in season the cells formed are smaller, darker, and have heavier walls (summerwood).

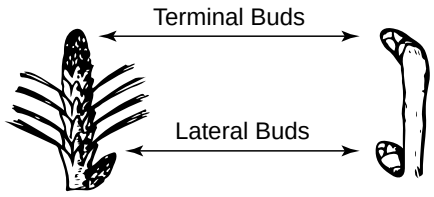


- When growth conditions are favorable and food and water are abundant, the rings are wide. Under unfavorable conditions, such as drought, the rings are narrow.
- By counting the annual rings, one can determine the age of a tree.

Height growth

Elongation from terminal buds produces height growth (the same is true of twigs and branches).

- Terminal buds complete growth early in the season, usually by the end of June.
- In many trees, all cell division for the next year's growth is completed in the bud by this time.
- The next season's growth takes place mostly by elongation of the bud cells formed in the previous year.
- Twigs and branches are formed from lateral buds.



Why do leaves change color?

A green leaf is green because of pigments known as *chlorophyll*. This green color masks out the colors of the other pigments. During the growing season, the plant replenishes the chlorophyll as it is used. As autumn approaches, chlorophyll is replaced at slower rate. This is when the green masking dwindles and the other pigments begin to show.

Lesson

2

Anthocyanins: These pigments causes the red and purple colors.
Carotenoids: These pigments causes the yellow, brown, and orange colors.These pigments exist in many living things, giving characteristic color to carrots, corn, canaries, bananas, and egg yolks.

Factors affecting leaf color

Leaf color can be affected by light (overcast or sunny periods), temperature, moisture, nutrients, and other factors. This is a complicated process, but, basically, the fall color change is the result of the depletion of chlorophyll, permitting the other dominating pigments to take over.

Lesson

2

ADDITIONAL ACTIVITIES

- Display a cross-section of a tree trunk and have students identify the outer bark, inner bark, cambium, sapwood, and heartwood: Point out the annual rings and have students determine the age of the tree when it was cut.
- Have students bring samples of terminal buds and lateral buds to class during discussion of height growth of trees.
- Have students collect leaves and make a bulletin board display illustrating why leaves change color in the fall.
- Arrange for students to visit a timber-cutting site, and have students determine the age and growth rate of selected trees.

SUGGESTIONS FOR STUDENT EVALUATION

- Give each student a diagram of a tree to identify the various tree parts and describe their functions.
- Have students complete a short test on tree growth or complete the activities suggested under the ***Application*** section.

SUGGESTED RESOURCES

Burton, L. DeVere. *Introduction to Forestry Science, Third Edition.* Independence, Kentucky: Cengage Learning Inc., 2013.

Rolfe, Gary L., et al. *Forests and Forestry*. Boston, Massachusetts: Pearson Education Inc., 2003.

Lesson

2

TEACHER NOTES

Identifying Trees

Lesson

3

SOL CORRELATIONS

Biology
BIO.7

English
9.1
9.5
9.6
10.6
10.8
11.5
11.6
12.1
12.5

EQUIPMENT, SUPPLIES, AND MATERIALS

- List of common and scientific names of trees common to Virginia
- Pictures of or samples from trees
- Document camera
- Tablet computer(s)
- Digital camera
- Laptop computer(s)

TEACHER: _____

SCHOOL: _____

GRADE LEVEL 9–12

TASKS/COMPETENCIES

- Identify Virginia native trees.
- Differentiate between forest types.

OBJECTIVES AND GOALS

- The student should be able to explain the importance of the scientific names of trees.
- The student should be able to identify the parts of a leaf.
- The student should be able to define terms related to leaf structure and arrangement (i.e., *sinus, vein, petiole, dentate, serrate, rachis, opposite, alternate, simple, compound, and lobe*).
- The student should be able to name and describe the forest types occurring in Virginia.

Lesson

3

ACTIVITIES

► Preparation

Lesson approach

To manage the forest properly, it is essential to recognize types of trees. Because trees are common features of the landscape and since the products derived from them are indispensable to our way of life, it is desirable to have a general knowledge of at least the common commercial tree species and their uses. The ability to identify trees further provides a better understanding of the world of nature and can add to our recreational enjoyment of the forest. Trees are important to wildlife and are essential elements in landscaping and beautification projects.

General situation

Not everyone knows how to identify the variety of trees in their own locality, and misidentification of species is common.

Local situation

On an informal walk around the school grounds or on an approved visit to an adjacent woodland (with principal and landowner permission), ask students to identify the most prevalent trees.

- Determine whether students simply identify the trees as pines, oaks, and gums.
- Determine the number of different types of trees in a given area.
- Identify which of these trees is commercially important.
- Have students prepare a digital slide show identifying the major species of local trees found on their walks. Slideshows should include a picture or diagram of the leaf, and the common and scientific name of the tree.

► Application

- Collect two (or three, if possible) different shapes of leaves from the same tree (e.g., sassafras, Southern red oak, water oak, or red mulberry).
- Collect two examples of simple leaves and two examples of compound leaves. (Virginia's most common compound-leaf trees are the black locust, honey locust, black walnut, white ash, or any of the hickories.)
- Collect leaves exhibiting different margins, including entire, serrated or toothed, and dissected.
- Collect leaves and cones of three types of pine.
- Collect leaves and acorns of a typical red oak and a typical white oak and label points of difference. (Members of the red oak family include the Northern, the Southern, the scarlet, the black and the pin oak, while members of the white oak family include the white, post, and the chestnut oak.)
- In late winter, collect six distinctive twigs to observe bud characteristics (a winter project). Observe differences in size, color, shape, and arrangement (alternate and opposite).
- Collect the leaves of two trees in the white oak group.
- Collect, mount, and label the parts of a typical red oak leaf.
- Collect leaves from 20 hardwoods and at least three local conifers.

► Presentation: Tree Identification

Nomenclature

It is not the purpose here to go deeply into scientific names. However, it is important to understand that for many of our common trees there are a number of common names. Loblolly pine, for example, has more than 25 common names in general use. Much confusion exists with the name poplar.

Each tree recognized as a distinct species has a scientific or a Latin name, which ultimately pins down its identification, for there can be only one tree with that scientific name. An excellent and thoroughly practical example of this is the Virginia pine, which is often called spruce pine, scrub pine, Jersey pine, or possum pine. Its scientific name is *Pinus virginiana* (named for Virginia), and it is known by this name throughout the world.

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These scientific names also serve to show the relationship of many of the trees. For example, sweet gum and black gum might be thought to be related. Here the word "gum" is meaningless. Each tree species has a generic name and a record name; for example, all pines are given the generic name *Pinus* and another name that identifies the particular kind of pine. In the case of sweet gum and black gum trees, *Liquidambar* and *Nyssa* show this lack of relationship, for they represent two different genera.

Remember, although there are many local common names for the same species throughout the state or nation, there is only one standard or scientific name attributed to each specific tree.

Identification features

The identification of a particular tree depends on observation of the parts of the tree and the knowledge of the location or area in which the tree grows. Refer to *Common Native Trees of Virginia* while studying the following identification procedures.

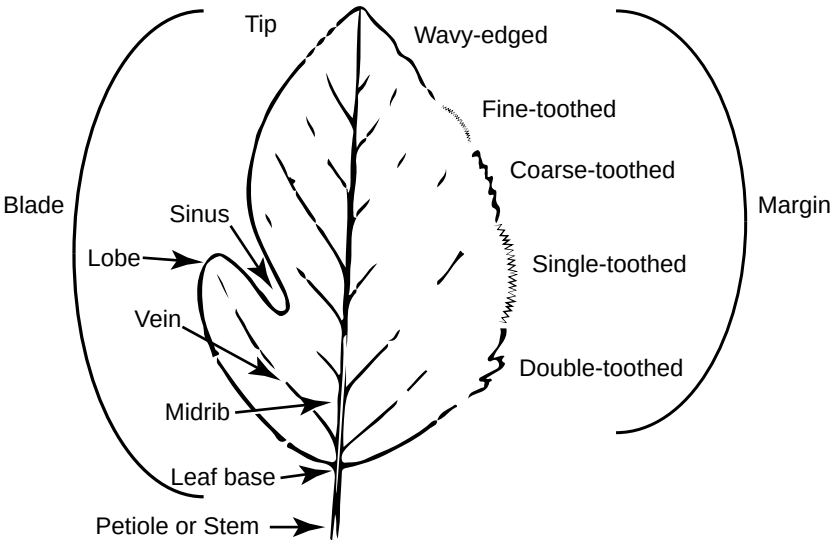
Leaves

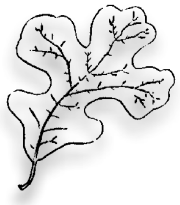
Leaves offer a simple means of identifying most trees. Unfortunately, this feature is not so useful in winter, although in some cases withered leaves might give a clue as to the identity of the trees. Then, too, a number of tree species have persistent green leaves throughout the winter (e.g., pines, spruces, hemlock, cedar, holly).

Parts of a leaf: Refer to the diagram below, which shows the essential parts of a leaf: midrib, margin, vein, petiole or stem, and base. These parts are often referred to in tree identification terminology.

Shape of a leaf: Shapes vary considerably from one species to another. In sassafras, red mulberry and water oak, there are considerable variations in the shapes of leaves found on the same tree. Refer to those species in the book *Common Native Trees of Virginia.*

Parts of a Leaf





Post Oak
(Simple Leaf)

Pignut Hickory
(Compound Leaf)

Some leaves are compound leaves; that is, they consist of a number of leaflets. The stem is called a *rachis.* A good example of this is the leaf of the hickory, depicted at left. Other trees having compound leaves are the walnut and the ashes, but most trees have simple leaves. In learning tree identification, care must be taken not to confuse an individual leaflet from a compound leaf with a simple leaf.

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Smooth Lobes
(White Oak Group)

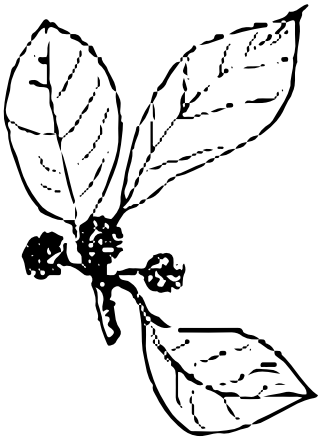
Bristled Lobes
(Red Oak Group)

Entire Margin
(Black Gum)

Toothed Margin
(Beech)

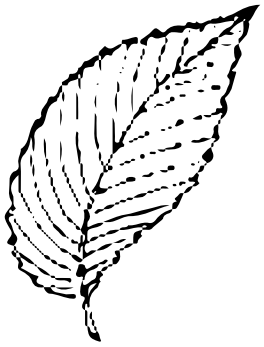
Double-toothed Margin
(American, Slippery, or Winged Elm)

Margins of Leaves



Entire Margin
(Black Gum)

Toothed Margin
(Beech)



Double-toothed Margin
(American, Slippery, or Winged Elm)

Margins of the leaf: Various dissections of the margin of the leaf are quite valuable in establishing a tree's identity. Some have *entire* margins, as illustrated by the black gum. Others are toothed or *dentate*; a common example of this is the beech. (The word *serrate*, meaning saw-toothed, is often encountered in the identification books; this is just a refinement for the term *toothed*.) Certain trees have leaves with *double toothing*, such as the elms, in which there is a smaller tooth on each tooth.

Dissected margins are most frequently found among the oaks. It is important to note that the oaks can be quite conveniently grouped into the red oaks and the white oaks, on the basis of the dissection. In the red oak group, the lobes are pointed and tipped with bristles. In the white oak group, the lobes are rounded and do not have bristles. See examples at left.

The deep indentations are referred to as **sinuses**, while the finger-like projections are called **lobes**.

Size of leaf: Size is often important for identification, especially when using a tree book; for example, in *Common Native Trees of Virginia*, the normal leaves of winged elm are said to be 4 to 6 inches in length, the needles of loblolly pine are 6 to 9 inches long, and those of shortleaf pine are only 3 to 5 inches long.

Color of leaves: Color is a useful identification tool in the fall, but even in spring and summer some leaves are of a much paler green than others are.

Pubescence of leaves: Sometimes the fuzziness is on the undersurface and sometimes only along the midrib. For example, the black oak is fuzzy along the midrib, whereas the Northern red oak is quite smooth throughout.

Arrangement of leaves: In Eastern white pine, five needles occur in a bundle; in loblolly pine, there are three long needles in a bundle; in Virginia pine, the needles occur in twos; in shortleaf pines, the needles might occur in twos and threes. Leaves may be attached opposite, or directly across from each other, or they may alternate along the stem in a more zig-zag fashion.

Avoidance of error in leaf identification

- Collect several leaves to get typical foliage. The leaves from higher in the tree may look a little more like those shown in most books.
- Avoid sprout growth. These leaves are often distorted beyond recognizable shape or a size, owing to the more vigorous growth of sprouts during their early years.
- Avoid collecting just the leaflets of compound leaves.

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Flowers

At certain times of the year, showy flowers of such trees as yellow poplar, magnolia, and dogwood can be used as means of identification.

Most tree species are wind-pollinated and have no need for showy flowers. However, flowers are of the utmost importance in the classification of all plants. For instance, the oak, beech, and chestnut are all placed in the family *Fagaceae* because of the close similarity of the flowers.

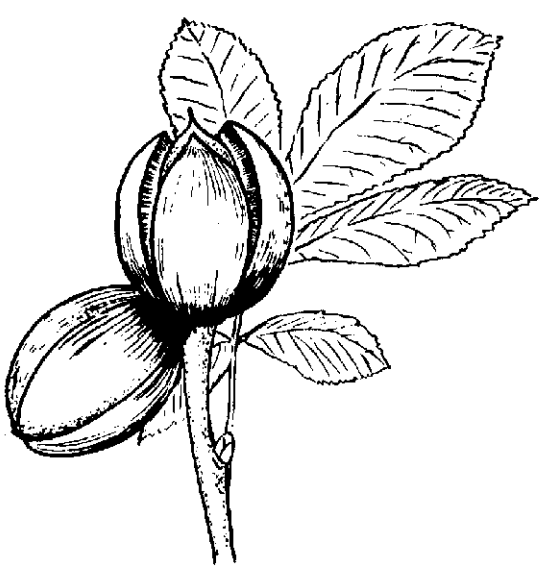
Fruits

Trees are often identified by means of the fruit they bear.

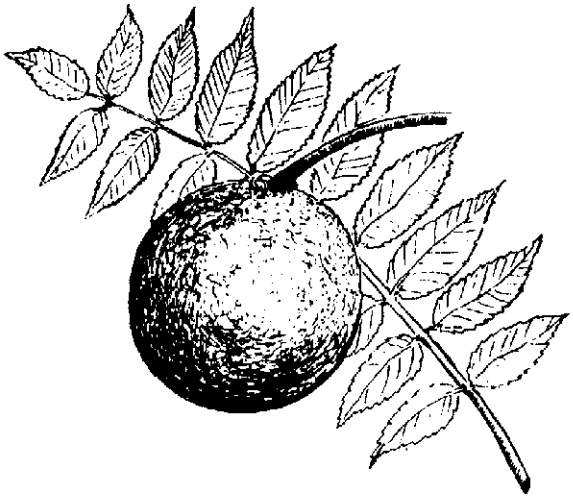
Nuts

Nuts are useful in pinpointing identification. For example, compare pictures of the nuts of mockernut hickory with those of pignut hickory in *Common Native Trees of Virginia*. Observe, too, a basic difference between walnut and hickory, as shown below. In the hickories the husk breaks up by means of distinct division (called *dehiscence*). It is interesting to note that the pecan is really just another member of the hickories. Other important nut-bearing trees are the beech and the chestnut.

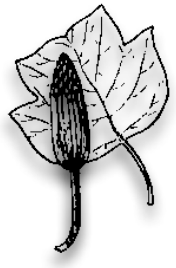
Examples of Nut-Bearing Trees



Hickory



Black Walnut



Yellow Poplar

White Ash

Red Maple

Berries and drupes

- Berries consist of seeds scattered throughout a soft fleshy substance. An example is the persimmon.
- Drupes have an outer portion (a fleshy, bony layer) surrounding pit or seed. Examples are black gum and black cherry. The blackberry is also a collection of drupelets.

Winged fruits (samaras)

These fruits are one-seeded and usually do not split open. Examples are white ash, red maple, sugar maple, and yellow poplar, as shown at left.

Cones

Variations of cones in size, shape, and arrangement on the tree are quite useful in identifying the conifers (softwoods). Spruce cones hang downward, while those of the balsam fir are erect.

Other fruits

- Pods are found on the black locust, honey locust, and redbud.
- Tufted seeds are found on the sycamore (after the balls break up).

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Other fruit characteristics

- Winter persistence is sometimes useful for identification. Examples of trees with fruits in the winter are the sourwood, sycamore, sweet gum, and holly.
- Seed dissemination methods give useful clues as to the identity of trees or groups of trees. Each tree has a particular way of getting its seeds scattered. (Seed dissemination is covered in more detail in a later unit.)

Twigs

Arrangement

Alternate and opposite twigs are useful identifiers. Maples, white and green ash, and dogwood have opposite twigs and branches. This is easily remembered by the acronym MAD, the letters of which stand for maple, ash, and dogwood.

Character of buds and leaf scars

- This is often a useful winter characteristic: Compare beech with white ash, for example.
- Some tree buds are hairy, while those of other trees are smooth.
- Color variations are often useful (e.g., red maple).

Bark

The identifying characteristics of bark, while difficult to describe, are useful:

- **Relative smoothness:** The bark of beech is quite smooth, while that of white oak is rough.
- **Color:** Sycamore bark has a variegated color pattern; in the persimmon, the bark is blackish.
- **Other individual tree characteristics:** The warty appearance of hackberry bark is quite characteristic and distinctive. The resin spots or dimple-like depressions in the bark of shortleaf pine are quite useful for identification.
- **General features:** Changes of color and general smoothness of bark are results of age. A good example is shown in loblolly pine. In young trees, the bark is dark and quite rough. As the trees mature, the bark breaks into rather smooth plates and acquires a reddish color.

General characteristics of trees

- **Normal shapes of crown and branching habit:** A good example of branching habit is exhibited by black gum, wherein the branches grow straight out from the tree. Elms often have the general effect of an inverted cone and can be identified at a distance.
- **Persistence of dead branches:** This is a useful feature when identifying scarlet oak and Virginia pine.
- **Buttressing or swelling of lower trunk:** This is characteristic of swamp species such as tupelo gum and bald cypress.

Habitat

Universal trees: Some trees, such as the white oak and black gum, occur in a wide variety of situations.

Topographic features: Most trees occurring in swamps and other wetlands are seldom found anywhere else. Trees of dry upland ridges cannot survive in swamps. Pin oak and sweet gum, for example, are species of the wet bottomlands, while scarlet oak and chestnut oak are trees of the upland dry ridges.

Nature of the soil quality: Black walnut and yellow poplar of any size are usually found only on good soil; blackjack oak and certain pines occur on poor or impoverished soil. Shortleaf pine and Virginia pine generally occur on dry soil; loblolly pine tends to thrive best on the moister soils.

Range

General: Yellow birch occurs in the mountainous part of the state; river birch occurs in the lower, swampier areas; red spruce is found only on the highest mountains; and bald cypress is found only in the swamps of the eastern part of the state. Many tree books have range maps showing the extent of the various trees. These are often quite accurate but are not absolutely reliable, especially along stream courses or places where there are slight climatic and topographic variations.

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Limits: Tree ranges are limited by soil and climate, and particularly by the delicate climatic conditions that exist at the time of pollination. For example, loblolly pine grows well when planted west of its natural range, but it does not produce seed reliably.

Other identification features

Hybrids: A number of trees freely hybridize. This is particularly true of the oaks.

Exotics: In the eastern and north-central parts of Virginia, which have been settled longer, numerous exotics have been introduced. Many of these have reproduced, and their progenies are often found in normal forest areas at some distance from towns and dwellings. Examples of these are princess tree (*Paulownia tomentosa*) and tree-of-heaven (*Ailanthus altissima*), both of which were introduced from Asia.

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ADDITIONAL ACTIVITIES

- Have students bring a list of all trees contained in their own wood lots or in the school forestry area; have them bring specimens from trees they cannot identify.
- Invite a local Virginia Department of Forestry representative to speak with students about ways trees may be identified.
- If a forested area is on school grounds, have students identify all the trees they can and label representative ones along the trail using ribbon and name tags.
- Have each student assemble a leaf collection, identifying as many different species of common Virginia trees as possible.

SUGGESTIONS FOR STUDENT EVALUATION

- Tests on tree identification can take the form of a field observation test, a written test, or an oral or written test using pictures of samples.
- On a field observation test, it is suggested that the trees be numbered, as in the FFA Forestry competition.
- For a written test, give students a list of the common names of trees and have them select answers for assignments 1 through 5.
  1. Name the three most common trees in Virginia that have opposite branching.
  2. Name five trees that have compound leaves.
  3. List 25 trees found in the local area.
  4. For each of the following features, provide an example tree:

alternate twigs	drupe	opposite twigs	toothed margin
berry	dry ridge habitat	simple leaf	winged fruit
compound leaf	entire margin	smooth bark	
dissected margin	nut	swampy habitat	

  5. Name two trees with showy flowers.
  6. Name the parts of a leaf.
  7. Describe differences between the fruits of the walnut tree and the hickory tree.

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SUGGESTED RESOURCES

*Common Native Trees of Virginia (*Virginia Department of Forestry): http://www.dof.virginia.gov/edu/resources/pub_Native-Trees-Va_2009.pdf

U.S. Department of Agriculture Forest Service; Northeastern Area Publications and Products: http://www.na.fs.fed.us/pubs/

Virginia Tech Tree Identification Fact Sheets: http://dendro.cnre.vt.edu/

Virginia Tech VTree database: http://dendro.cnre.vt.edu/dendrology/factsheets.cfm

What Tree Is That? Tree Identification Field Guide: http://www.arborday.org/trees/treeID.html

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TEACHER NOTES

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Viewing the Forest as a Community (Ecology)

SOL CORRELATIONS

Biology
BIO.5
BIO.8
BIO.9

Earth Science
ES.7
ES.9

English
9.1
9.5
9.6
10.6
10.7
10.8
11.5
11.6
11.8
12.1
12.5
12.6
12.8

EQUIPMENT, SUPPLIES, AND MATERIALS

- Instructor-provided research guidelines
- Art supplies
- Diagrams illustrating plant succession

TEACHER: _____

SCHOOL: _____

GRADE LEVEL 9–12

TASKS/COMPETENCIES

- Explain basic tree structure and growth.
- Define *forest ecology*.
- Explain principles and processes of ecological succession.
- Describe the effects of climate, latitude, and topography on species diversity.
- Describe ecological concepts of shade tolerance and species competition.
- Identify common forest soil characteristics.
- Differentiate between forest types.
- Describe the relationship between living organisms and the environment.
- Describe the hydrological cycle, streams, and watersheds.
- Describe how land use and other human activities affect soil, water, and vegetative resources.
- Identify the different roles of government, industry, and private forestry agencies.

OBJECTIVES AND GOALS

- The student should be able to define *forest ecology* and state why the study of ecology is important to forest management.
- The student should be able to identify the site factors that influence the distribution and growth of trees or plants.
- The student should be able to explain how temperature, moisture, wind, sunlight, lightning, and heavy snow influence tree growth.
- The student should be able to define the following terms:
  - ◊ *Topography*
  - ◊ *Altitudinal zonation*
  - ◊ *Slope*
  - ◊ *Aspect*
  - ◊ *Dominant*
  - ◊ *Co-dominant*
  - ◊ *Intermediate*
  - ◊ *Sup*pressed
- The student should be able to identify the soil factors that influence tree growth.
- The student should be able to identify the beneficial and adverse biological influences affecting growth of trees.
- The student should be able to identify examples of five types of seed dissemination.
- The student should be able to explain why knowledge of plant succession is important to forest management.
- The student should be able to name the factors of competition for tree growth in the forest.
- The student should be able to identify the characteristics of even-aged and uneven-aged stands of trees.

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ACTIVITIES

► Preparation

Lesson approach

To manage the forest or wildlife area properly, it is essential to know something about the life of the forest and to regard it as a community of plants and animals. An understanding of the nature of plant communities is useful in a number of ways, such as wildlife improvement, erosion control, fishing stream and pond improvement, and weed control.

General situation

In areas where the important tree species occur as even-aged forests, many people try to manage them as uneven-aged forests. Often they attempt to reproduce, manage, or plant trees in unsuitable areas and have a poor understanding of the quality of the site.

Local situation

Begin with a discussion of the forest and soil types found in the area. Select the most important local forest type and study what happens when it is cut. Outline the general bare-land plant succession for the region and prepare or obtain appropriate diagrams.

► Application

The following field observation assignments are suggested for viewing the forest as a community.

- Seek out an old, abandoned field nearby and try to determine the year it was abandoned. Describe the present vegetation.
- Visit cut-over forestlands and report present species. Try to date the cutting by determining the age of trees that have come up since the cutting. Also, visit a forest fire area and determine what changes have taken place.
- Visit various vegetative types or situations and list the types of trees found in each. Critically examine the same timber type in a stream bottom and on a nearby ridge; measure the tree heights and ages.
- View a marsh, swamp, upland ridge, rock area, rich hardwood soil, and an abandoned field, and describe the vegetation found in each.
- Visit a pine woods. What is the difference in age? Are vigorous young pines present or absent?
- Visit an old-growth hardwood forest and report on the types of trees found in the undergrowth. What is the most abundant species there? Turn over a few old logs, notice the decay, and describe the animal life found there.

► Presentation: The Forest as a Community

Background information

As we begin the study of forestry, it soon becomes apparent that we must have a good understanding not only of trees and their growth but of the forest or group of trees as a whole. Here we are concerned with the forest as a community of plants and not merely as an assemblage of trees occurring in a disorderly assortment. Until the forest or the specific timber stand is recognized as a living community, it cannot be intelligently managed. In other words, before we can make further progress in the application of forestry principles, we must realize that each forest unit is a result of several factors working together, factors over which we sometimes have little, if any, control. These are basically the environmental factors that influence or often preclude certain types of forest (plant) growth.

Under certain conditions, thriving forests can be expected; under other conditions, certain trees or plant species will be missing. Under still different sets of environmental conditions, there may be no forest as we conceive it, yet there may be a great assemblage of other plants (e.g., a salt marsh or a rock outcropping with an extremely thin soil). Every group of trees or plants has optimum and minimum growing conditions. Some trees are adaptable to a wide range of suitable situations. We must attempt to understand these environmental factors and how they influence the growth and development of the forest community. This is the subject of ecology, the science that deals with the relations between plants and animals and their environment. The word *ecology* is derived from the Greek word

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eco, meaning home.

Site factors

What controls the distribution and best growth of trees or plants? Why are the forests and animals of Surry County different from those of Buchanan County? Why are the forests of eastern Virginia different from those of western Virginia?

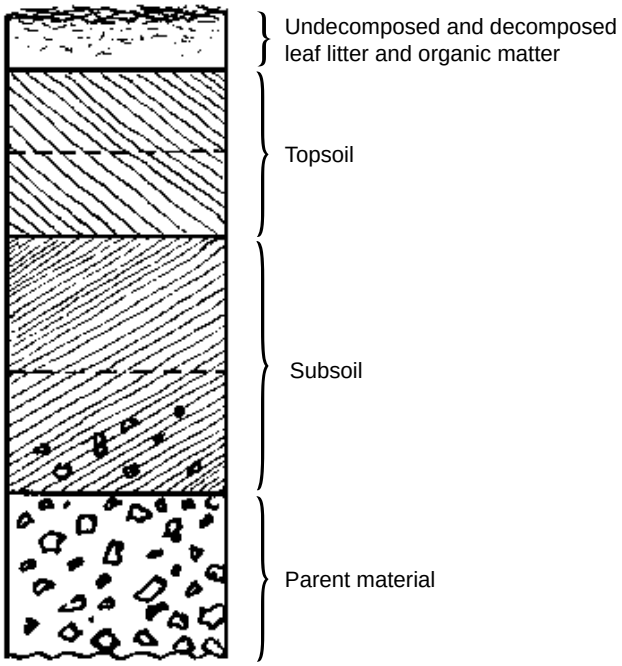
Climatic factors

- **Temperature:** Mean annual temperatures, extremes, and duration of growing season influence the type of plant growth. In the far north, the frozen soil prevents tree growth.
- **Moisture:** In Virginia, moisture is usually in the form of rainfall. Some types of trees require little moisture; others must have plenty. To withtstand drought, many plants have developed special adaptations, such as waxy, thick leaves and short, active growing seasons during periods of rainfall. Humidity is often important.
- **Wind:** In high mountains, wind produces distorted or limited growth.
- **Solar radiation:** The amount of sunlight influences tree growth.
- **Other weather conditions:** Lightning or heavy snow influence tree growth, mostly in high mountains and in the far north. Some trees cannot resist snow and sleet damage—this limits northern colonization of southern trees.

Physiographic factors

Topography: Topography influences local climate and affects the type of soil and the degree of erosion. Two areas in Virginia—the Dismal Swamp and Whitetop Mountain—owe their great differences almost entirely to topography. To some extent, there is an *altitudinal zonation* of plants. For example, Fraser fir and red spruce are trees found only in the highest mountains of the state.

Profile of a Typical Undisturbed Forest Soil



Slope or aspect is of great importance in the mountains. In this sense, the terms *slope* and *aspect* refer to the direction of exposure of the mountainside. Certain kinds of trees thrive and grow better on northern slopes than on southern slopes, and in the natural forest, northern and southern slopes will have quite different forest vegetation. As a general example, northern red oak might occur on the northern slope, while chestnut and scarlet oak occupy the southern slopes. Hemlock at low elevations is usually found only on northern slopes, while at higher altitudes it is more universally distributed. Swamps and bottomlands are topographic features. The difference between them is that the swamp is subject to frequent prolonged inundations, and only trees that can tolerate great amounts of water can grow in such situations.

- **Soil factors:** A general agricultural knowledge of soils is essential to the understanding of forest ecology. The typical forest soil profile is that of undisturbed soil, and the soil has a definite layer of litter and duff. The following factors can affect the suitability of forest soils for the various species of trees:

- Past human use, including forest fires
- Depth and texture of topsoil (water-retaining capacity)
- Nature of subsoil

- Leaching out of nutrients in certain soils
- Soil moisture conditions
- Soil acidity and alkalinity
- Organisms of the soil

Biological factors

Certain animals and plants on a site can influence tree growth:

Beneficial influences

- Insects that pollinate plants
- Soil organisms and organisms producing decay of leaves, logs, and roots
- Predators, such as hawks, owls, and foxes, that control injurious rodents and seed consumers

Adverse influences

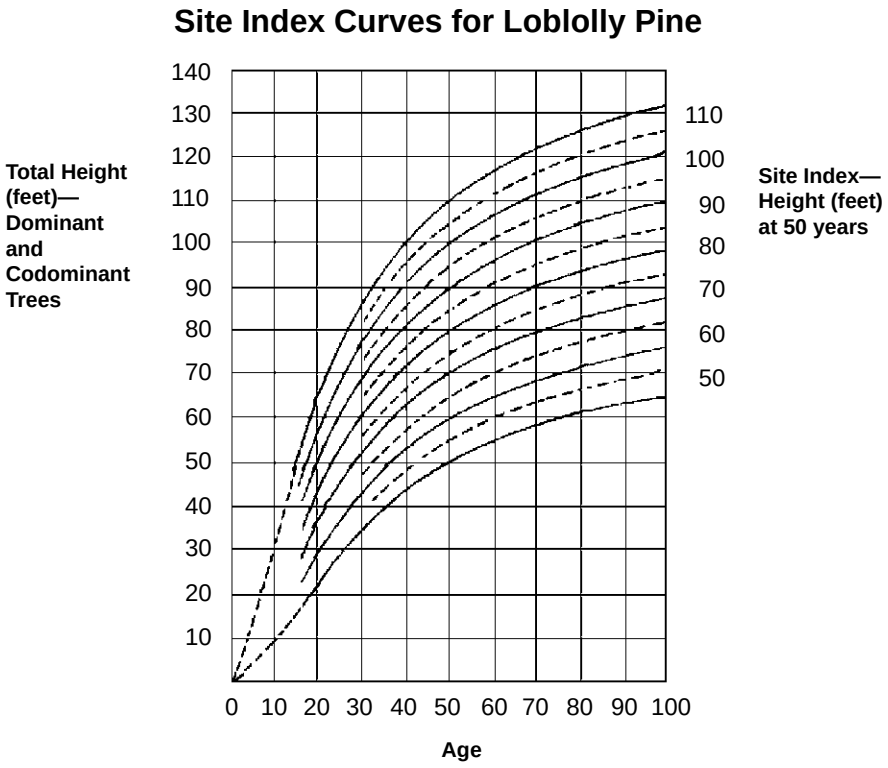
- Grazing livestock
- Overpopulation of wildlife, such as rodents and deer, that destroy young trees
- Insects and tree diseases
- Plants, such as honeysuckle or kudzu, which strangle forest growth

Determination of site

Foresters determine the site quality of even-aged stands of timber by measuring the total height of the dominant trees and obtaining the age of the trees. The height attained at 50 years is called the site index of that soil for the particular species. If a red oak had reached 80 feet at 50 years, it is on site index 80, which is good for oak.

If the trees are not 50 years old, the site is determined from a set of curves designed for each species. For example, if loblolly pine is 90 feet high at age 40, it is on site index 100, which is very good. If at 40 years it has only become 60 feet high, it is on site index 67—a poor site.

Indicator plants are often useful in judging loblolly pine sites. The presence of yellow poplars in the pine woods indicates a good pine site. A heavy growth of lichens (reindeer moss) indicates a poor pine site.



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Seed dissemination

The earth is constantly being supplied with all sorts of seeds, spores, and eggs. The plant kingdom has developed a number of interesting methods of seed dissemination, all for the purpose of regeneration and the colonization of new areas.

- **Wind:** Certain seeds, such as winged seed (pine, yellow poplar, ash, and maple) and tufted seed (thistle, dandelion, sycamore, and willow) are disseminated by the wind.
- **Animals:**
  - ◊ Fruits serve as a temptation or a bribe to an animal or bird to carry seed to a distant place.
  - ◊ Hitchhikers, beggar lice, and sheep burrs are clever means of dissemination through passing animals.
- **Water:** Seeds of the swamp species (cypress and tupelo) are often transported by water to distant areas.
- **Ejection:** Some seeds, when ripe, are violently ejected by specialized fibers in the pods. Some seed containers are designed like little salt shakers (e.g., seedbox).
- **Special adaptations:** The seed of the mistletoe has a glue-like substance that enables it to stick to a tree when carried there by a bird.
- **Gravity:** Nuts and acorns can fall and roll to new places.

Only a small number of the seeds that are transported ever germinate and grow. Many are eaten by animals, birds, and insects; others fall during adverse situations or on the wrong type of soil. Of the millions that actually germinate, only a few survive to develop. For example, observe the mass of spores put forth by a puffball fungus, or consider the millions of eggs laid by certain fish or insects. Only a tiny fraction ever develops.

It should also be noted that many plants can reproduce themselves vegetatively by sprouting, layering, and suckering.

Plant succession

There is no such thing as a permanently bare land area, at least in our region. Land that becomes denuded by forest fire, clearing, mining, rock slide, or sand dune encroachment does not stay bare for long.

Almost immediately, life reinvades such areas in an orderly and progressive manner. The cleared field, upon its subsequent abandonment, is the most common bare area in this region, and in Virginia we have ample opportunities to observe this process. Rock slides, sand dune encroachment, or mining operations represent an extreme situation; nevertheless, even these areas gradually become revegetated and continually improve toward what is known as the climax—nature's final expression for that region.

In the eastern Virginia uplands, this climax is a forest of oak, hickory, and beech. In some parts of the mountains, owing to climatic differences, the climax might be one of beech, maple, and birch. All parts of the world have their own characteristic climax vegetation. An area might never quite reach this climax, but the vegetation constantly aims toward it.

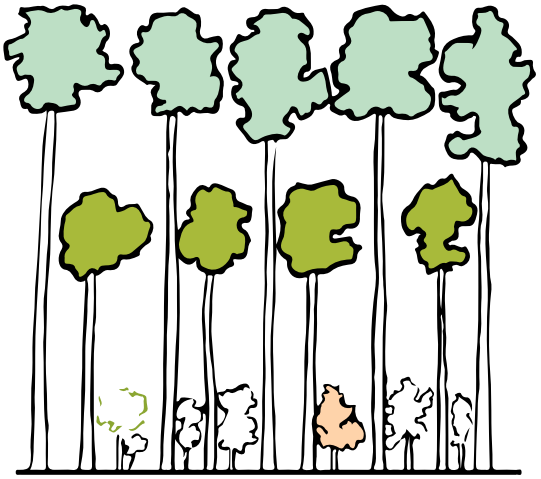
Classic ecological examples of climax vegetation are to be found in the northern states where a retreating glacier left areas of denuded bare rock and thousands of gouged-out basins became lakes and ponds. Now, many thousands of years later, this vast area is fully clothed in forest or prairie vegetation. Many of the lakes have silted full and are now part of the forest; other lakes are destined to become filled.

The most outstanding example of this orderly progress of plant succession is the case of Indonesia's Krakatoa volcano, which erupted in 1883 and denuded adjacent areas of all life. The vegetation returned, and the study of its development and progress has given the science of ecology a rich example of the tendencies of natural vegetation to repossess a bare area in an orderly fashion.

The study of plant succession, therefore, should teach us that the vegetative units we observe from day to day, and perhaps take for granted, have arrived at whatever stage we observe in a well-ordered

Lesson

4



and almost predestined manner. What at first appears to be a wild profusion of masses of vegetation will, on a second look, show us that the plants are arranged in definite sequences in relation to each other, to the animal life present, and to the environment. A forest area on good soil will be stratified from top to bottom.

First in the stratification are the dominant trees, forming the canopy. The second layer consists of shade-enduring trees, of smaller stature but in place eventually to poke their way upward and become the dominant forest. In a pine forest, the secondary layer might be of oak, hickory, beech, or other hardwoods. Below this second layer is a layer of shrubs adapted to withstand shade. Below these shrubs are the herbaceous plants of the forest (certain grasses, ferns, and other plants) and under them are various mosses and lichens. In the soil, other plant and animal organisms are found which relate to the condition of the forest's development.

With an appreciation of this orderliness and the progress of vegetation from bare soil to climax forest, we are ready to make a practical study of local and common plant succession, starting from an old abandoned field. This is called secondary succession, for the soil of the old field or burned area is receptive to the seeds that will bombard it.

Example of normal upland abandoned field succession in most of Virginia:

Year 1: Following abandonment, the area is dominated by various weeds and grasses.
Year 2: There is a gradual encroachment of other herbaceous plants. A few pine seedlings might begin showing up.
Year 3: Broomsedge becomes dominant; more pine seedlings appear.
Year 5: Pine overtops the broomsedge and weeds.
Year 10: Pines form a rather dense, closed canopy; broomsedge and weeds disappear.
Year 20: A few hardwood seedlings begin showing up.
Year 40: The pine is middle-aged. A hardwood understory has developed—gum, maple, and hickory.
Year 80: Pine is overmature and the hardwood growth, now principally oak, hickory, and beech, forges ahead and replaces any pines that might die out.
Year 150: The forest is now one of oak, hickory, and beech and reproduces itself in its own shade. The pines have become little more than scattered relics. The climax has been reached.

On poorer soil, the time taken to reach the various stages would be much longer. Cutting of the larger pines when they have attained sawlog size merely hastens the process toward a hardwood forest.

In modern forestry, following the cutting of pine timber or in converting cut-over hardwood areas to pine, the forester can take advantage of fire as a means of reducing unwanted brush growth back to the bare-field condition. This is called a prescribed burn. Unlike wildfires, prescribed burns are set under safe conditions, often for the purpose of properly starting a new forest of pine or the valuable hardwoods.

Lesson

4

Prescribed burning represents a practical application of knowledge of plant ecology in forest management.

Stand competition

In the realm of nature there is competition among plants for sunlight, moisture, and nutrients for growing space. When this competition becomes intense, the plants or animals that are poorly adapted to the particular environment quickly lose in the struggle.

Factors of competition

Sunlight: All trees require sunlight. Some require full sunlight; others can stand some shade. When one tree of the same species is able to grow taller than the next tree, it gets most of the sunlight and the other one gradually loses out. A young pine under hardwood does not receive full sunlight, but when the hardwoods are cut or killed, this form of competition is removed.

Growing space: There is room for a limited number of trees or plants in a given area. In the case of trees, this limit diminishes with increasing size or age. As a stand of young trees gets older, the trees get larger, make more demands on the soil, and have to develop as large a crown as possible. Only those trees that can get ample space will be able to get the necessary sunlight. It must be remembered, too, that the roots are in competition for space in the soil.

Soil moisture: Competition for soil moisture is often quite serious among trees. When all trees are competing for moisture, only the strongest will get an ample supply. Some kinds of trees require a great deal of moisture, while others require little. It must be remembered that all soil moisture is not always available to the tree. Some trees can take up more moisture from the soil than can others.

Soil nutrients: The nutrients in the soil are unavailable to the plants unless the soil moisture is there to carry nutrients in solution. Thus, soil moisture is the most important competition factor. However, some kinds of trees require more of a certain element (e.g., potassium) than others. If there is not enough available potassium in the soil, the potassium-demanding tree cannot compete with the tree that does not need as much.

Effects of competition

- More adaptive trees usually win the struggle. The trees of the area might gradually be replaced by trees that are better adapted to the slowly changing conditions.
- Certain trees of the same species are, by inheritance, less vigorous and are quickly crowded out. For example, trees that are inherently weak from the standpoint of height growth could easily be overtopped by better trees with good height-growth possibilities.
- The different species all grow at slightly different rates, and each makes a particular demand on the soil. Only certain mixtures of trees can grow together and really thrive, and these types of trees will dominate the others.

Tolerance

Tolerance is generally taken to mean the ability to withstand adverse conditions. Often this is reflected in the ability of certain kinds of trees to withstand shade. Such a tree is called a shade-tolerant tree. Trees that cannot stand shade are called intolerant trees.

A good example is the comparison between American beech and loblolly pine. Beech is tolerant of shade, and we find young beech trees doing well under heavy shade. Loblolly pine cannot stand shade, and we seldom find it growing under shade. All trees seem to be tolerant during the first four or five years of their lives; after that time, however, the intolerant species quickly die out.

General Tolerance Table for Common Virginia Trees		
Tolerant **(can endure heavy shade)**	Moderately Tolerant **(can endure some shade)**	Intolerant **(can endure little or no shade)**
Hemlock	Sweet Gum	Loblolly Pine
Beech	White Pine	Shortleaf Pine
Sugar Maple	White Oak	Pitch Pine
Dogwood	Hickory	Virginia Pine
Red Spruce	Black Oak	Black Walnut
Red Maple	Sycamore	Yellow Poplar
Black Gum	Northern Red Oak	Cypress
Basswood	Southern Red Oak	Black Locust
Sourwood	Yellow Birch	Willow
	White Cedar	Eastern Cottonwood
	American Elm	

Source: Adapted from *Foundations of Silviculture*

Dominance

As a result of the competition in even-aged stands (trees of essentially the same age), the better trees soon forge ahead of the others. These become known as dominants. Others in a slightly less favorable position are called co-dominants. Below the co-dominants are the intermediates, which receive sunlight only from the top, and below these are the suppressed trees, or those below the general crown level.

Dominant, *co-dominant*, *intermediate*, and *suppressed* are forestry terms mentioned only to emphasize that as a result of competition, the trees or plants rather quickly become segregated into classes as fewer of the better trees forge ahead and dominate the inferior ones of the same species.

It should be realized, too, that mixtures of different species growing at different rates will end up with the faster-growing species as dominants, and unless the slower-growing ones are tolerant of shade, they will rapidly lose out in the struggle. Judgment must be used in selecting species for mixed planting.

Forest types

Definition

A forest type is a community or association of certain types of trees. Some are pure and others are mixtures. The following broad classes of timber can be considered the important forest types of Virginia:

- Pine
- Pine-hardwood
- Mixed hardwood
- Bottomland hardwood
- Swamp hardwood
- Cove hardwood

Concept of types

In considering the forest as a community, it is apparent that a particular species or group of species dominates each community. These species or species groups are usually the result of the following:

- Soil condition
- Moisture relations

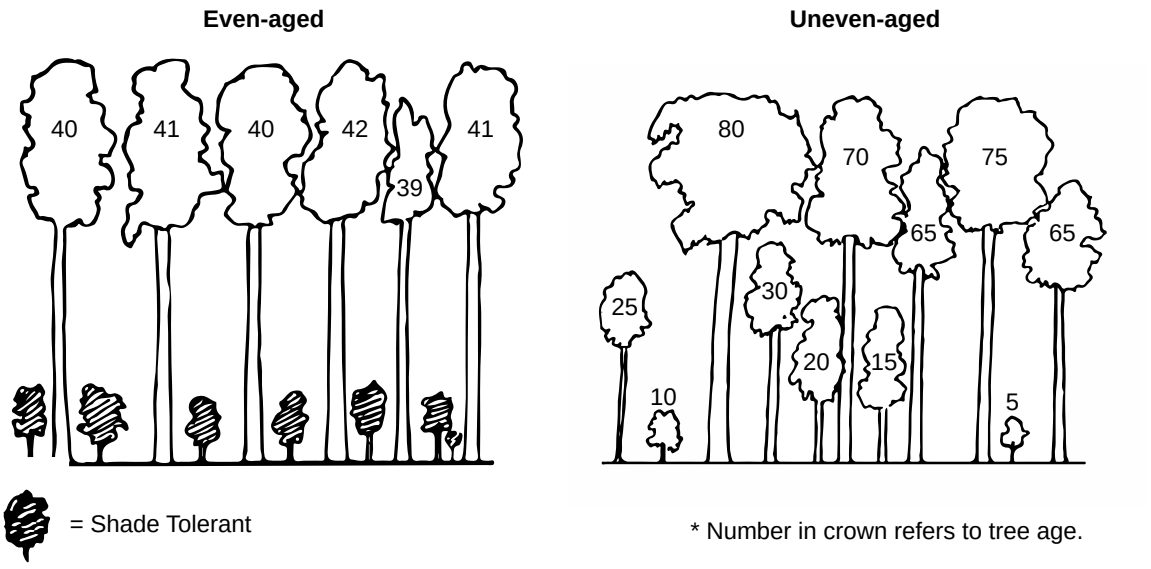
- Past treatment
- Logging of particular kinds of trees (converting a pine-hardwood to a mixed hardwood)
- Clearing and later abandonment
- Grazing, including wildlife influences
- Forest fire
- Draining or flooding
- Elimination or reduction of certain tree species by insects and diseases

Use of types

All forest management practices should be considered in terms of forest types, using the type as the unit of treatment:

- for organizing the forest for management
- for timber estimates and valuations
- for various cultural activities
- as cutting areas in carrying out the forest-management plan.

It is possible for a forest to change the types; for example, if a mixed-hardwood type is cut over and planted to pine, it becomes a pine type. If a pine-type forest is clear-cut, without cultural work it could easily revert to a mixed-hardwood type.



Even-aged and uneven-aged stands

From the discussion of plant succession, tolerance, and competition, it should now be obvious that we cannot manage a forest unless we have some understanding of these terms. In agriculture we must understand the nature of a crop before we can produce it. We plant certain crops on certain soils and prescribe programs of cultivation accordingly. The forest is managed similarly.

One of the essentials of timberland management is to distinguish between even-aged and uneven-aged stands. Most of our really productive forests are even-aged in character. That is, all of the trees are essentially of the same age. A stand of pine originating on an old field is even-aged because the seedlings all germinated during the same few years. Later arrivals perished in the competition because they were not tolerant. In such a forest we often find trees with various diameters, the result of competition, not of difference in age. The increment borer, or a count of stump rings in a cutting, quickly proves this. If the trees were all different ages, they would be different heights, and an intolerant species such as pine or yellow poplar could not thrive under the overhead shade of the so-called older trees.

Lesson

4

Characteristics of the even-aged forest

- All trees of the same general age (within ten years)
- Understory of different, usually tolerant species
- Composed of trees of the same general height-growth characteristics
- Tend to be pure stands or composed of relatively few species
- Tree components generally intolerant

Characteristics of the uneven-aged forest

- Theoretically, trees of all ages, often found in even-aged patches
- Understory often same species as overstory
- Considerable variation in height-growth characteristics
- Most tree components tolerant, generally capable of reproducing in their own shade

Lesson

4

ADDITIONAL ACTIVITIES

- Discuss the forest types found in the local area and the types of soil on which they occur.
- Discuss the influence of site factors such as climate, topography, soil, wildlife, insects, livestock, and tree diseases on tree growth and forest competition.
- Illustrate the concept of plant succession with the use of appropriate diagrams.
- Discuss the factors of stand competition (e.g., sunlight, growing space, soil moisture, soil nutrients) and the effects of each on forest management.
- Discuss the various methods of seed dissemination.
- Assign various field observation projects to individuals or groups of students to illustrate plant succession and stand competition.

SUGGESTIONS FOR STUDENT EVALUATION

- Distribute and discuss the guidelines and references related to a paper on the influence of climatic, physiographic, and biological factors on the forest. Evaluate according to the report guidelines.
- Prepare a written quiz on the tasks, competencies, objectives, and goals as noted at the beginning of Lesson 4.
- Prepare written or oral descriptions of field observations described in the Application section. Prepare a checklist for evaluation of the descriptions.

SUGGESTED RESOURCES

Gagnon, Jennifer. *Virginia Master Naturalist Basic Training Course: Forest Ecology and Management in Virginia.* Blacksburg: Virginia Tech, Virginia Cooperative Extension, 2013. http://pubs.ext.vt.edu/465/465-315/465-315_pdf.pdf

U.S. Department of Agriculture Forest Service map of Forest Cover Types in the United States: http://www.fia.fs.fed.us/library/maps/docs/forestcover.pdf

Lesson

4

TEACHER NOTES

Lesson

5

SOL CORRELATIONS

Earth Science
ES.3

Mathematics
A.7
G.8
G.9
G.13
G.14

EQUIPMENT, SUPPLIES, AND MATERIALS

- U.S. Geological Survey maps of the local area (online)
- U.S. Department of Agriculture aerial photos of local area (online)
- Engineer's scale or ruler with one-tenth-inch divisions
- Steel tapes
- Surveyor's tape
- Compass
- Topographic maps
- GPS and Google Earth
- computer access

Reading and Interpreting Maps and Aerial Photographs

TEACHER: _____

SCHOOL: _____

GRADE LEVEL 9–12

TASKS/COMPETENCIES

- Describe topographic map, relief map, aerial photography, and virtual soil maps.
- Identify specific landmarks on a topographic map.
- Locate known landmarks on a topographic map and a relief map.
- Use proper equipment (e.g., clinometers, GPS, transit level, rod) to determine slope and distance.
- Demonstrate the ability to determine distance and slope with a topographic map.
- Explain the parts of a field map.
- Use a compass and map to conduct a land-navigation exercise.
- Research mapping programs (e.g., computer, software).

OBJECTIVES AND GOALS

- The student should be able to identify two types of maps and explain the major differences between the two types.
- The student should be able to define the following terms:

Azimuth	*Magnetic north*
Bearings	*Magnetic pole*
Direction	*Prime meridian*
Elevation	*Relief*
Geographical	*Pole surveying*
Latitude	*True north*
Longitude	

- The student should be able to explain how latitudes and longitudes are numbered.
- The student should be able to explain how maps are scaled.
- The student should be able state four uses of topographic maps.
- The student should be able to interpret various maps for correlation to geographical features.
- The student should be able to list the purposes of surveys.
- The student should be able to take accurate field notes.
- The student should be able to identify and use surveying equipment correctly.
- The student should be able to determine the location of points on a land surface.
- The student should be able to run a closed traverse.
- The student should be able to determine the area of a closed traverse.
- The student should be able to identify the importance of aerial photographs in map preparation.
- The student should be able to explain how aerial photographs are scaled.
- The student should be able to identify uses of aerial photographs.

Lesson

5

ACTIVITIES

► Preparation

Lesson approach

- Maps are used in the study of history, geography, economics, and many other study areas. Road maps are perhaps the most familiar. But with a little knowledge and training, we should be able to use topographic maps, virtual soil survey maps (available through the U.S. Department of Agriculture), and aerial photographs just as effectively.
- To use maps efficiently for locating and describing physical and topographical elements of the terrain, a basic knowledge of map features, map symbology, and principles of interpretation is needed.
- Aerial photographs are used to construct topographic maps and to keep the map information up to date. The best conditions for evaluating and interpreting terrain include using a good topographic map and recent aerial photographs.
- Aerial photographs and virtual maps allow the user to see the lay of the land and physical features of the earth clearly. They can be used to supplement and clarify topographic maps.

General situation

- Land is often bought and sold without reference to its actual location on maps or aerial photographs.
- Boundary lines, roads, fences, and rights-of-way are often mislocated or even "lost," which may result in court cases and ill feelings between neighbors.
- Forest products are sold with written contracts; however, the description of the land from which it is to be removed is given verbally, and its exact location may be in error.
- The proper use of maps can increase the efficiency and ability of land appraisers, contractors, and engineers.
- There are many job opportunities available in the wood-using industry for people skilled in the interpretation and proper use of maps.

Local situation

- Determine the following information from students:
  - ◊ Virtual maps are available for all of Virginia land areas from USDA, and thus all landowners have an online map available. (See the USDA link in "Lesson approach.")
  - ◊ How would they locate their land or a particular parcel of land with only a verbal (legal) description?
  - ◊ How was the acreage on their farm estimated?
  - ◊ How would they go about locating the best place for a main road or a new power line right-of-way to a specific location on the farm?
- If the majority of students in the class do not live on a farm, the material should be modified to reflect suburban or urban uses of maps.

► Application

- Have each student study a U.S. Geological Survey quadrangle sheet of the local area. Point out the map symbols, legend, and the representations of elevation and relief.
- Select a tract (at least 50 acres in size) in the local area that can be located on the topographic map from a legal description.
- Have students study the terrain of the tract carefully on the map; measure the distance and direction of the boundary lines or selected roads within the tract; then determine the acreage of the tract, using the dot-grid method (http://www.wetmaap.org/References/dot_grid.html).
- Arrange to have students visit the selected tract. Have them use the topographic map to navigate to the property and study the map representation of elevation and relief, comparing them to their actual appearance. Photographs of objects and areas of the tract can be taken and compared to the map symbols.
- Locate the same tract on Google Earth using a street address.

Lesson

5

► *Presentation: Maps and Aerial Photographs*

Understanding maps

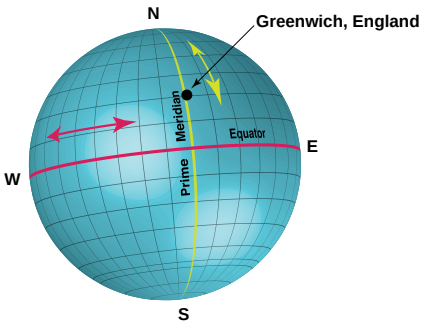
A map is a graphic representation of Earth's surface or part of it, drawn to scale on a plane, with human-constructed and natural features depicted by symbols, lines, and colors.

Types of maps

- A *planimetric* map shows only the horizontal (flat) position of constructed and natural features (e.g., highway map).
- A *topographic* map depicts the horizontal and vertical (relief) positions of constructed and natural features. The distinguishing characteristic of a topographic map is the portrayal of the shape and elevation of the terrain with lines, colors, and symbols.

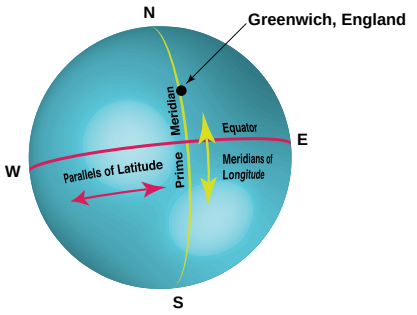
Map coordinates

Two-dimensional geographic coordinates are based on distances from an east-west line running through the equator and from a north-south line running through Greenwich, England. The line from the North Pole to the South Pole running through Greenwich is called the prime meridian.



Latitude: the distance of a point north or south of the equator is known as its latitude, and the rings around Earth parallel to the equator are called the parallels of latitude.

Longitude: the distance of a point east or west of the prime meridian is known as its longitude, and the rings around Earth at right angles to the equator passing through the poles are known as meridians of longitude.



Angular measure with geographic coordinates

The unit of angular measure is the degree. Each circle is divided into 360 degrees, and each degree is 60 minutes. Starting at the equator, parallels of latitude are numbered from zero to 90 north and zero to 90 south. Direction north or south must always be given, since latitude can have the same numerical number on either side of the equator. The poles are at 90 north and south latitude.

Longitude lines are numbered zero to 180 east and west of the prime meridian. The line directly opposite the prime meridian may have a value of 180 east and 180 west.

At any point on Earth, the ground distance covered by 1 degree of latitude is approximately 69 statute miles. The ground distance covered by 1 degree of longitude is approximately 69 miles at the equator but decreases as one moves north or south to the poles until it becomes zero.

Map scales, directions, and symbols

Map scales

The scales printed on a map permit the determination of ground distance. To bring a map down to a useful size, everything on it is reduced in size at a uniform rate. The amount that objects have been reduced is indicated by the scale of the map.

Representative fraction (RF): The scale of a map expresses the ratio of the horizontal distance on the map to the corresponding horizontal distance on the ground. The RF expresses this relationship as a fraction or ratio (e.g., 1:24,000 or 1/24,000). The numerator, always written as 1, represents the map distance; the denominator, a larger number, represents ground distance. The RF is independent of any unit of measure and is written as:

The ground distance between two points on a map is determined by measuring the distance between them on the map and multiplying the map distance by the denominator of the RF.

Graphic scales: A graphic scale is a ruler printed on the map from which distances on the map may be measured. The straight-line ground distance between two map points is determined by measuring the map distance with a ruler or a pair of dividers, then comparing this distance directly with the graphic scale.

Direction and azimuth

The direction of any line is the horizontal angle that it makes with the standard direction. The most important instrument for direction determination is the magnetic compass.

Magnetic vs. true direction: The point of the compass needle marked *north* points to the north magnetic pole rather than toward the north geographical pole (true north). This direction is called *magnetic north*. The angle formed between magnetic north and true north is called *magnetic declination*.

Azimuth: An azimuth is defined as a horizontal angle measured in a clockwise direction from a base line. Azimuths have values from 0 to 360 degrees.

Bearings: Bearings are horizontal angles referenced to one of the quadrants of the compass (i.e., NE, SW, SE, NW). Bearings are measured clockwise and counterclockwise from north or south to east or west.

Color codes for map features

Symbols depicting natural and constructed map features are usually printed in different colors to provide a more natural appearance and color. Each color represents a class of features. The color codes are as follows:

- Black—the majority of cultural and human-constructed features
- Blue—water features such as lakes, rivers, and swamps
- Green—vegetation such as woods, vineyards, and orchards
- Brown—the shape and elevation of the topography
- Red—boundary lines, large highways, and special features
- Occasional other colors—special information indicated in the legend

Elevation and relief

Elevation: The height of land surfaces in feet above sea level is called elevation.

Relief Relief is the variation in elevation of the earth's surface. Relief occurs in forms of hills, valleys, ridges, and the like.

Uniform Gentle Slope

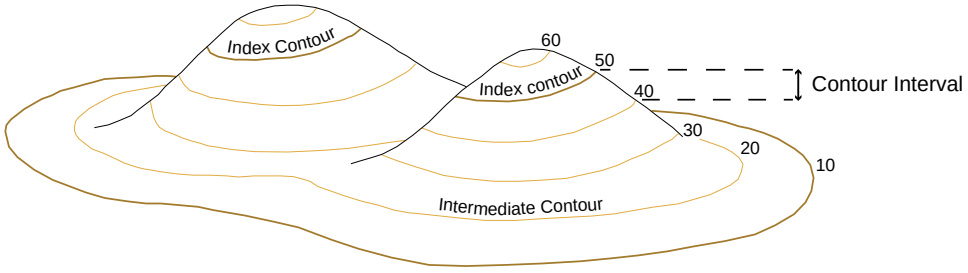
Uniform Steep Slope

Representations of elevation and relief

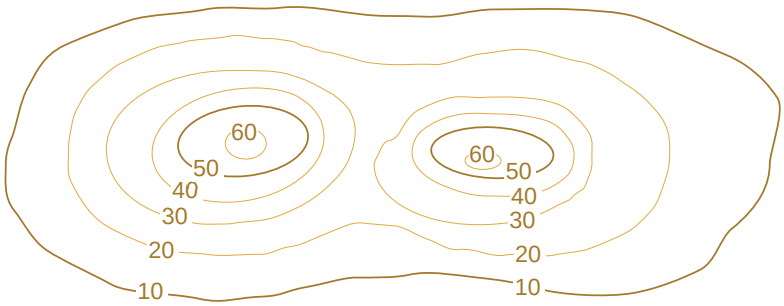
The method most commonly used for representing elevation and relief is *contouring*. Other methods include the color-layer system. The color-layer system of color shading makes use of special arrangement of colors; each color represents a certain interval of elevation. The color scale for the elevations is shown in the map legend.

Contour lines

A contour line is an imaginary line on the ground connecting points of the same elevation. Contour



Saddle between Two Hills (Side Perspective)



Contour Lines of a Saddle (Map Perspective)

lines indicate a vertical distance above or below sea level. The vertical distance between adjacent contour lines is known as the *contour interval*, and the amount of the contour interval is given in the marginal information. On most maps the contour lines are printed in brown. Starting at the lowest elevation, every fifth contour line is heavier and darker than intermediate contours and is known as an index contour. Along each index contour the line is broken at some place and its elevation given. The contour lines falling between index contours are called *intermediate contours*. They are drawn with a thinner line than index contours and usually do not have the elevation given.

The spacing of the contour lines shows the relief. Contour lines evenly spaced and wide apart indicate a uniform gentle slope. Contour lines evenly spaced and close together indicate a uniform steep slope. The closer the contour lines are together, the steeper the slope.

Uses of topographic maps

Topographic maps are used for area measurement, road planning, agricultural planning, and recreation development.

Fundamentals of aerial photographs

Aerial photographs are photographs taken from aircraft. Through measurement of aerial photographs, it is possible to construct accurate maps containing a great deal of information about land forms, vegetation, and cultural features on the surface of the earth.

Information appearing on aerial photographs

- The agency responsible for the photograph is listed on the back.
- An alphabetic code for the county, a flight line number, and the photograph number appear in the upper right-hand corner.
- Date of photography appears in the upper left-hand corner.
- Time of photography may appear to the right of the date on the first and last photograph of a continuous strip.
- Fiducial marks (half-arrows or small crosses) appear either in the four corners or midway along the border of the print. The intersection of lines connecting opposite fiducial marks locates the optical center of the photograph, known as the principal point.
- Scale of the photograph may appear on the face or stamped on the back of the photograph.

Photograph scale

- **Area determination:** The numerical scale of a photograph or map depicts the relationship of the distance measured on the map or photograph to the distance measured on the ground, and

is called the representative fraction (RF). The area on a photograph (or map) is determined as the square of the denominator of the RF. For example, an RF of 1:15,840 means that 1 inch equals 15,840 inches, or 1 inch equals 1,320 feet, or 1 inch equals 20 chains (66 feet per chain). Therefore, 1 square inch on the photograph equals 400 square chains, or 40 acres.

- **Compass bearings:** Few flight lines are oriented in exact cardinal directions (north, south, east, or west); therefore, a reference line of known direction must be established before bearings to various objects can be determined.

The single aerial photograph is not a map because of image displacements due to topography and photographic tilt. *The photo scale is only constant on the datum plane.* An accurate map cannot be constructed or traced *directly* from photographs unless the mapped ground is perfectly level and the photographs taken with no appreciable tilt.

Uses of aerial photographs

- The advantages of aerial photography lie in the accuracy and speed for obtaining information of the physical features of relatively large, often inaccessible areas.

Area measurement

- There are several methods for estimating size of irregular areas. Three of the more common methods include planimeters, grids, and the polygon feature on the USDA soil survey maps.
- **Planimeters:** The planimeter is a mechanical device consisting of several small wheels, a numerical dial, and a tracing area. The boundary of the area is traced with the point on the tracing arm in a clockwise direction, and area in square units can be read on the instrument dial. Planimeters yield accurate measurements if carefully used.
- **Grids:** Grids consist of intersecting lines forming rectangles or squares, which are drafted onto the map or photograph or simply superimposed by means of a transparent overlay. Each grid or square is assigned an area value according to the scale of the photograph. For instance, if a grid contains 1,000 squares and 450 of them fall in a particular area, the size is thus 450 times the acreage or the area of an individual square. A modification of the grid called the *dot grid* consists of systematically placed dots on a transparent plastic overlay. The dot grid is placed over the photograph or map and the number of dots falling within the effective area are counted. The acreage per dot is multiplied by the number of dots to obtain the total acreage. These overlays are available from suppliers of forestry materials.
- **Polygon:** The polygon is a tool available to calculate acreage on online soil survey maps where the area is irregular or not aligned to a north-south orientation. This tool makes the use of planimeters and grids obsolete.

Lesson

5

ADDITIONAL ACTIVITIES

- Display examples of planimetric and topographical maps, and discuss the purpose and uses of each type. Ask the following questions:
  - ◊ How can land be located from a verbal or legal description?
  - ◊ How can acreage be estimated?
  - ◊ What methods can be used to locate the best place for a main road or new power line right-of-way to a specific location?
- Present examples of cases in which maps were used or could have been used to prevent misunderstandings or financial loss.
- Have students practice locating assigned locations on topographic maps.
- Display examples of aerial photographs and compare them with corresponding maps. Have students identify objects in aerial photographs.

SUGGESTIONS FOR STUDENT EVALUATION

Interpretation of the map symbols, legend information, and the representations of elevation and relief on a U.S. Geological Survey map of the local area may take the form of written or oral tests.

SUGGESTED RESOURCES

4-H Compass Traverse Contest References: http://4hforestryinvitational.org/training/compass-traverse-contest/index_html

4-H Tree Measurement Contest References: http://4hforestryinvitational.org/training/tree-measurement-contest

4-H Topographic Map Contest References: http://4hforestryinvitational.org/training/topographic-map-contest/index_html

The National 4H Forestry Invitational training site has great explanations of multiple parts of forestry: http://4hforestryinvitational.org/training/

U.S. Department of Agriculture Web Soil Survey: http://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm

U.S. Geological Survey Education, Find a Map!: http://www.usgs.gov/education

U.S. Geological Survey Maps, Imagery, and Publications: http://www.usgs.gov/pubprod/aerial.html

Lesson

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Surveying The Forest

ACTIVITIES

► Preparation

Lesson approach

- Surveys are performed for different purposes, but the primary reasons for surveys of forestland are to determine boundaries and acreage of a given tract of forestland.
- Harvesting operations are often arranged with approximate descriptions of the woods to be cut. To protect the forest owner and logger, exact boundaries should be established. The most precise method of determining boundaries is by survey.
- It is essential in effective forest management to know the acreage of tracts to be used, improved, or harvested.

General situation

- Land is sometimes bought and sold without reference to its actual location on maps or aerial photographs. The same lack of specificity often applies to forest products.
- Boundary disputes often arise between neighbors and municipalities.
- Surveys, used alone or in conjunction with existing maps, are performed to solve problems arising from inexact descriptions or boundary disputes.
- Surveys are used to create and update maps, to locate roads, and to determine land configurations.

Local situation

- Determine whether any students (or their families) have had their land surveyed; if so, ask them about the purpose of the survey.
- Determine whether there is new road construction underway in the local area and point this out as an example of the use of survey.
- Review elements of map and aerial photograph interpretation before embarking on a study of surveying.

► Application

- Arrange to have students observe a survey crew in action.
- Arrange for access to forestland and have groups of students survey the tract by running a closed traverse.
- Have students compute acreage by using the polygon feature on a computer, and using a soil survey map available from USDA.

► Presentation: Forest Surveys

Definition of surveying

Surveying is the art of locating points of lines on or near the surface of the earth by measuring angles, directions, and distances.

Types and purposes of surveys

- Control surveys determine horizontal position and elevation.
- Topographic surveys determine ground configuration.
- Surveys determine the direction and length of lines.
- Boundary surveys determine the position of property lines and enclosed areas.
- Construction surveys determine the position of buildings, roads, dams, and other structures.

Accuracy and precision

Regardless of the type of survey, a good surveyor must produce accurate and precise results. Before

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starting any survey, the surveyor or forester must decide on the accuracy desired for a project (usually based on cost). Many forestry applications do not require precise instruments; for example, less-precise instruments such as a compass to measure angles and directions, taping or pacing to measure horizontal distances, and an Abney level or clinometer to measure differences in elevation and vertical heights, are satisfactory for many surveys.

If greater accuracy is desired, more precise instruments are used, such as a transit or theodolite to measure angles, directions, or elevations and a steel tape with temperature and tension corrections to measure distances. This unit will concentrate on the use of less-precise instruments that are much simpler and faster to use but still provide the accuracy required for many forest surveying situations.

Measurement of horizontal distances

Units of length

The basic units of length used in the United States for forestry applications are the foot (ft), meter (m) and the surveyor's tape (or Gunter's chain), measuring 66 feet. The foot is used in English-speaking countries, and the meter has become the adopted unit for international and scientific usage.

For foresters, the chain is a convenient and popular dimension of horizontal measurement. The unit of land measurement is the acre, standardized at ⅛ mile (660 feet) in length and 1/80 mile (66 feet) in width. When using a 66-foot chain, an acre becomes 10 chains long and 1 chain wide, or 10 square chains in area. Areas expressed in square chains can be easily converted into acres by dividing by 10.

Listed below are the equivalents of the different units.

- 1 mile = 5,280 feet = 1,760 yards = 320 rods = 80 chains
- 1 chain = 66 feet = 4 rods
- 1 meter = 39.37 inches = 3.2808333 feet = 1.0936111 yards
- 1 acre = 43,560 square feet = 10 square chains

Instruments and methods

Measurement of horizontal distances is essential to the inventory forester, who often must retrace old property lines, survey new tract boundaries, or determine land areas. Distances can be determined by several means, but pacing and measuring with steel tapes are the methods most often used.

Steel tapes

- Engineer tapes are made of metal and come in 100-, 200-, and 300-foot lengths. Most tapes are graduated at every foot, with the first and the last foot subdivided in 1/10- or 1/100-foot increments for measurement of fractional distances. Engineer tapes also can be further divided into adding and subtracting tapes, which have extra graduations beyond the zero mark. When using an adding tape, the fractional part is added on to the measurement held by the rear chainer. With a subtracting tape, the fractional part held by the head chainer is subtracted from the measurement held by the rear chainer.
- A surveyor's tape (or Gunter's chain) is also a steel tape, but with different graduations. Generally 2 chains, or 132 feet long (plus trailer), the tape is divided into links that are 1/100 of a chain (0.66 feet or 7.92 inches).

Pacing

Pacing is the least accurate method for distance measurement, but accurate pacing is a valuable asset to the timber cruiser working alone. Pacing is commonly defined as the average length of two natural steps. For best results, a natural walking gait is recommended because it can easily be maintained under rough terrain conditions. Pacing uniformly is difficult in hilly terrain because slope distance rather than horizontal distance is being measured. Pacing uphill or downhill compensations for slope must be made by adjusting or skipping a pace at certain intervals.

For instruction in pacing, a horizontal course (five to ten chains) should be measured and staked out on level ground.

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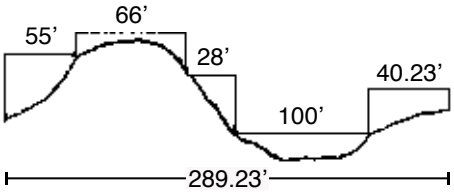
After establishing a consistent gait, the student should pace the measured course several times until an average number of paces per chain can be determined.

Measuring level ground with steel tapes

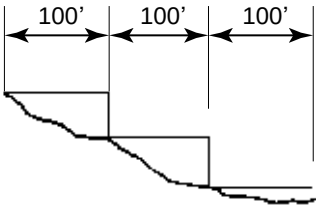
Accurate measurement (also called chaining or taping) of distances with a steel tape requires a two-person survey crew consisting of a head chainer and a rear chainer. On level ground, chaining is a simple operation using 11 chaining pins and a steel tape. Beginning at the point of origin, a chaining pin is placed after the "zero" point and the head chainer moves ahead with the remaining 10 pins. When the end of the tape approaches, the rear chainer shouts out, "Chain!" Both crew members pull the tape taut until the rear chainer calls out, "Stick!" After marking the point with a pin, the head chainer replies, "Stuck!" The procedure is repeated until the desired measurement has been taped. As chaining proceeds, the rear chainer keeps the head chainer on a straight course and also collects the chain pins until a 10-chain interval has been measured.

Measuring slope with steel tapes

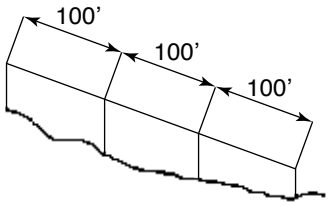
Since acreage is always measured by horizontal distance, in rough and mountainous terrain, horizontal distances may be measured by one of two methods. The first method is called breaking chain, because only short sections of the tape are used to maintain and measure a level line.



In the second method, foresters may use a one- or two-chain trailer tape and an Abney level with a topographic scale graduated in percentages of 66 feet. The head chainer moves up or down the slope until the full length of the tape is reached. The rear chainer determines the slope percentage (using the Abney level) between his or her position and the head chainer's. Using the slope percentage correction table (or slope correction graduations on the tape), a correction adjustment is made by adding the proper number of links from the trailer tape. The tape is again stretched tight, a new pin is set, and the correct horizontal distance is marked and recorded.



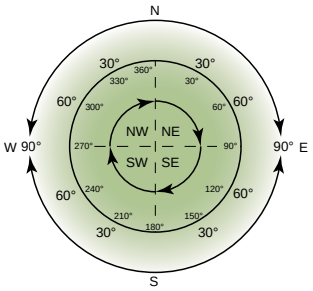
Horizontal Slope



Steep Slope

Measurement of direction

A fundamental purpose of surveying is to determine the locations of points on the land surface. To fix the position of a point, the angles, directions, and distances must be determined. Horizontal angles are the basic measurements for determining bearing and azimuths.



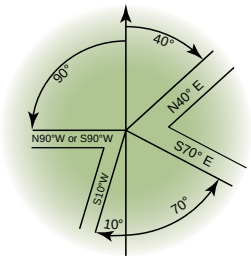
Relationship of Bearings and Azimuths

Azimuths

Another system of designating directions is the azimuth, which varies from zero to 360 degrees. An azimuth is the angle a line makes with the true north-south line (meridian) and is always measured in a clockwise direction from due north. Azimuths are generally true or magnetic, depending upon the meridian used.

Bearings

The use of bearings is one system of representing directions of lines. The bearing of a line is the acute horizontal angle between it and a reference line (meridian). The angle is always measured from north and south to east or west, dividing the circle into quadrants of 90 degrees each. Bearings never exceed 90 degrees and are always referenced to one of the quadrants



True Bearings

of the compass (NE, SE, SW, NW).

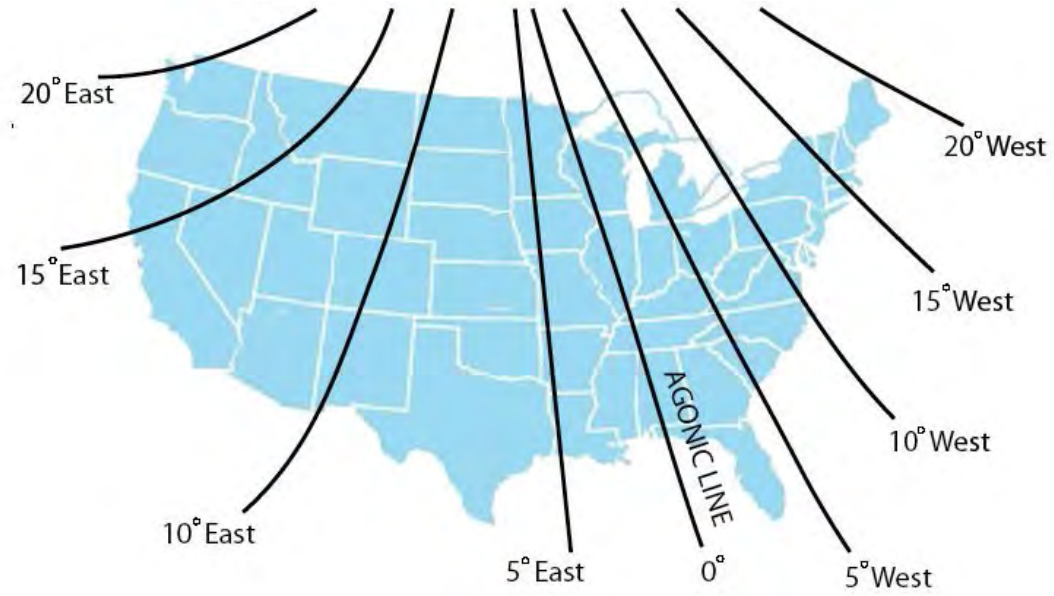
Magnetic declination and local attraction

The angular difference between magnetic north and true north is called declination. Because the earth acts like a magnet, corrections are necessary (for either east or west declinations) to compensate for compass distortions caused by Earth's magnetic field. The amount of magnetic declination changes from place to place and from year to year. Isogonic charts are issued periodically and used to determine exact declinations.

Compass readings used in establishing and retracing property lines are generally recorded as true bearings or azimuths. Therefore, adjustments for magnetic declination can be made by setting the correct allowance directly on the compass. As long as the declination does not change, all compass readings will be in true bearings (and azimuths) rather than magnetic.

Other local magnetic attractions may also cause a compass to read incorrectly. When surveying near ore and mineral deposits, fence lines, or electrical transmission lines, care must be taken to keep these conditions from affecting compass readings.

Isogonic Lines Showing Magnetic Declination



Source: U.S. Geological Service

Instruments and use

For most forestry applications, the compass remains the main instrument used for angle measurements. A compass consists of a magnetized steel needle (which points toward magnetic north) mounted on a pivot at the center of a circle graduated in one-degree units. There are many types and brands of compasses, but foresters commonly use either the hand compass or the staff compass.

Hand compass: The hand compass is held with both hands about chest high. Bearings are determined by sighting along the desired line through a notched sight in the compass box. The bearing of the line is then determined by reading the degrees shown on the compass dial when the needle and the orienting arrow correspond. A viewing mirror aids in sighting the bearing line and turning the compass dial simultaneously.

Staff compass: A staff or surveyor's compass is a box compass very much like the hand compass, but instead of being hand-held, it is supported by a wooden "Jacob's" staff (or tripod). The staff is placed firmly in the ground and the compass box is attached and leveled, using a circular leveling vial. The compass also has a device for clamping the needle securely (for transporting) and an exterior screw for changing the declination. Bearings are determined by sighting through two vertical sighting vanes that are aligned on the north-south axis. Direct readings of bearings (in degrees or half degrees) are

shown on a circular scale at the outer rim of the compass box. Accuracy of the staff compass, when used in conjunction with a steel tape, is approximately 1/300. (For more exact surveys where greater accuracy is required, a vernier transit should be used.)

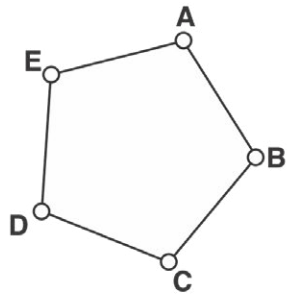
Boundary surveys and traversing

Boundary surveys

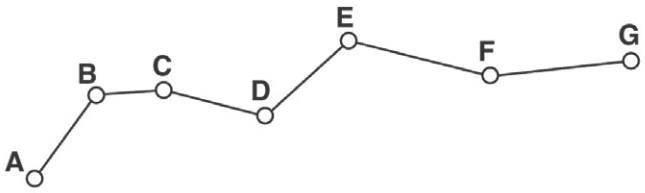
Foresters survey the boundaries of a timber tract to establish exact property lines, to locate timber-cutting areas, and to determine the area of a tract. Occasionally, land surveys are used to locate fences and firebreaks; to plan for logging roads, skid trails, and log-loading areas; to locate water drainages, culverts, and bridges; and to map timber types, soil series, watersheds, or recreational areas.

Traversing

A surveyor traverse is defined as a series of consecutive lines whose lengths and directions have been determined by field measurements. There are two basic types of traverses: closed and open. A closed traverse begins and ends at the same point and forms a closed polygon of an undetermined area. An open traverse generally begins at a known point and consists of a series of connected lines that terminate at an unknown position.



Closed Traverse



Open Traverse

Method of running a traverse

Most boundary surveys or closed traverses require a three- or four-person crew. The crew generally consists of a party chief who serves as a compass operator and note keeper, two people who chain horizontal distances, and a fourth person who handles the range poles at each compass setup.

Beginning at a known corner (A), the surveyor's compass is set up and a compass bearing (foresight) is made to the next corner (B). The compass operator records the foresight (nearest degree), and the two chainers tape the distance between points A and B. At point B, the compass is again set up and a bearing reading back to point A is taken. This is termed a backsight and is used to check for local attraction and accuracy of the foresight. The survey from point B to point C and other points in the traverse are made in the same way as from A to B. All foresights, backsights, and distances are recorded in the field notebook. Normally, the fourth person in the survey party places a range pole at each point, which acts as a temporary marker until a wooden stake can be driven into each corner station. Each traverse station is designated as A, B, C, D, and so forth.

Determination of area

After the closed traverse is plotted, several methods can be used to compute the area enclosed within the survey boundaries.

Cross-section squares

Assuming the traverse is plotted correctly, the enclosed area can be determined graphically by computing the area of the small squares found on the cross-section paper. The total acreage can be easily found by counting all the small squares enclosed within the plotted traverse.

Triangulation

Most tracts can be divided into triangles by connecting the various plotted points. Having done this on

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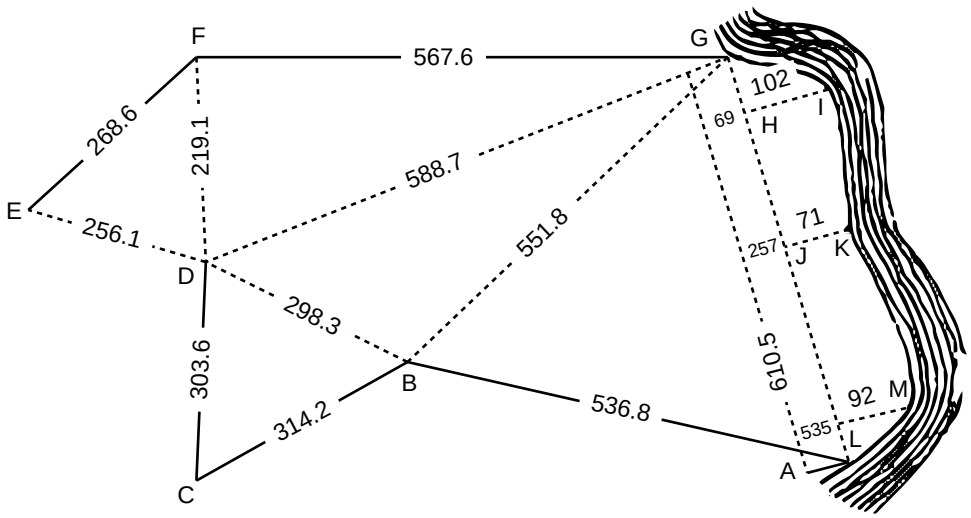
the plotted traverse, the area of each triangle is computed. The sum of all the areas of the triangles is the total tract area.



Area Determination by Triangles

Planimeters

Polar planimeters are instruments used to trace the outline of the plotted traverse area. As the boundaries are traced, the planimeter mechanically records the area in square inches and is read directly from the vernier scale. With this information, the total area of the traverse can be determined by converting the square inches to the scale of the map.

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ADDITIONAL ACTIVITIES

- Discuss the types and purposes of surveys.
- Have students list reasons for accuracy and precision when surveying.
- Display surveying equipment and explain the function of each instrument.
- Have students work problems requiring conversion from one basic unit of length to another (e.g., acres of miles to chains).
- Arrange a demonstration of and have students participate in the surveying of a particular forest tract that includes level ground and slope.
- Demonstrate and have students run a closed traverse and determine the area of the traverse.
- Have students calculate acreage on a given land area using a virtual map.

SUGGESTIONS FOR STUDENT EVALUATION

- Students may participate in a survey crew.
- Students may determine acreage to the nearest hundredth of an acre.

SUGGESTED RESOURCES

Forest Mensuration: Quantify the Current Forest: http://fennerschool-associated.anu.edu.au/mensuration/BrackandWood1998/WHATNOW.HTM

U.S. Department of Agriculture Web Soil Survey: http://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm

TEACHER NOTES

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Lesson

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Managing the Forest (Silviculture)

TEACHER: _____

SCHOOL: _____

GRADE LEVEL 9–12

SOL CORRELATIONS

Biology
BIO.1
BIO.9

English
9.1
9.5
9.6
10.1
11.5
12.1
12.5

EQUIPMENT, SUPPLIES, AND MATERIALS

- Increment borer, diameter tape, or Biltmore stick
- Abney level

TASKS/COMPETENCIES

- Outline procedures for managing harvesting operations.
- Develop a plan (e.g., recreational, wildlife, timber, revenue, aesthetic) for the management of a forest.
- Explain the concepts of multiple-use management (e.g., relationship and interaction between discipline areas and agencies).
- Identify the steps to conducting a prescribed burn.

OBJECTIVES AND GOALS

- The student should be able to identify the factors that comprise a stand analysis.
- The student should be able to state reasons for intermediate cuttings.
- The student should be able to explain the process, application, and advantage of selection cutting in uneven-aged stands.
- The student should be able to identify the disadvantages of cutting of even-aged stands to a diameter limit.
- The student should be able to explain how reproduction can be secured when clear-cutting even-aged stands.
- The student should be able to state the requirements and advantages of Virginia's Seed Tree Law.
- The student should be able to identify the steps in the process of shelterwood cutting.

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ACTIVITIES

► Preparation

Lesson approach

- Once established, a forest will probably grow by itself. However, application of established management practices can improve the quantity and quality of wood products in a given forest area, thereby increasing the income from the woodland.
- These management practices have evolved from an understanding of how trees grow, which tree species produce the most valuable products, and under what conditions certain trees grow best.
- Since tree species vary in their requirements as to soil, moisture, climate, ability to endure shade, and other factors, the most suitable management practices must be determined for each local area.
- In addition to the production of timber products, the forest has other uses, such as watershed protection, wildlife habitat, and recreation, which may be the best use for a forest in a particular location or circumstance.

General situation

- Forest industry and government own 23 percent of Virginia's forestland.
- The remaining 77 percent of the forestland is owned by private landowners.
- To meet the future needs for forest products, private landowners must increase their forest production through good management.

Local situation

The following questions should be answered during class discussion and illustrated through field observations:

- What percentage of the local forestland does forest industry and government own?
- What percentage of the local forestland is privately owned?
- What common trees grow in the local area?
- Are the local timber stands generally even-aged or uneven-aged?
- Which trees sell best, are the most profitable, have good markets for their products, or grow best in the local forest?
- What general harvesting practices are the most widely used in the local area, and do these practices contribute to best production in the long run?
- What happens to the undesirable, unsellable trees? Are they left to grow and occupy valuable space? Will the managers of the forest restock with similar low-value trees?
- Is erosion a hazard as a result of cutting operations in the local area, and, if so, are watershed values usually protected by proper planning of skid roads?

► Application

Instruction in forest management depends to a large extent on excursions to illustrate cutting, thinning, and planting methods and to give students practical experience in planning improvement of timber stands. The following activities are suggested:

- Assign each student a plot on which to perform and record a stand analysis.

Circular Plot Dimensions

Plot Area	Radius in Feet
1/2 acre	83.26
1/4 acre	58.88
1/5 acre	52.60
1/10 acre	37.24

- Arrange for students to see several age classes of immature timber to illustrate various types of intermediate cutting.
- Arrange for students to see several mature stands of timber and have students recommend harvesting methods.
- Contact a forest industry representative or local forester for assistance in locating areas in which cutting is taking place.

- Arrange for students to visit sites that illustrate the various types of cutting. Have students observe the results obtained on areas previously cut.
- Arrange for students to visit logging areas and have students examine them for active erosion. Point out how proper planning and layout of skid roads can prevent erosion.
- Number 25 trees in an immature pine stand. Have students decide whether to take or leave each numbered tree, and give reasons for their decisions.

► *Presentation: Forest Management*

Stand Analysis

Our first consideration must be to determine what conditions exist in the woodland to be managed. To do this, we must take a close, careful look and note the important facts.

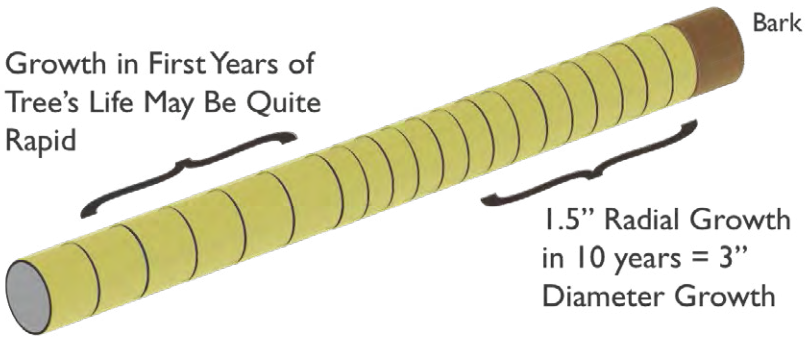
Composition of the stand: What species of trees are present?

Forest types: In what proportion are these different species present? (See Lesson 4 for definition of forest types.)

Age: What is the age of the important species? By using an increment borer or by counting growth rings on a recently cut stump, we can determine whether the stand is immature or mature.

Age distribution: Using the age count, we can determine whether the stand is even-aged or uneven-aged. A stand is usually considered even-aged if there is less than 10 years' difference between individual trees. This will be a guide to later recommendations of management practices.

Growth rate: Still using the same increment core or stump, we can determine the growth rate. One accepted means of expressing growth rate is by measuring the radial growth in the last 10 years and doubling it to determine the diameter growth of the tree during this period. In assessing this figure, we must remember that young trees normally grow rapidly. However, as the diameter of the tree increases, a much narrower ring may represent a proportionately larger volume growth. As a rough guide, we may assume that for trees up to 30 years of age, good growth would equal approximately 3 inches of diameter growth in 10 years. On older trees, a smaller increase of about 2 inches would be classified as satisfactory.



Size: Using a Biltmore stick or diameter tape, we measure the diameter at breast height (dbh), 4½ feet from the ground, of the trees on the lot. The Biltmore stick can also be used to measure the height of the trees suitable for sale in 16-foot logs or number of 5-foot sticks of pulpwood. (See Lesson 8 for definition of products.)

Trees per acre: This figure is especially important in young pine stands to help determine the need for thinning.

Quality of site: From the condition of the trees and our knowledge of tree requirements, we determine whether the site would be good for growing this species.

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Products available: Decide which products should be made available now or those which should be managed to produce in the years ahead.

Reproduction: Is reproduction present and, if so, for which tree species is reproduction necessary or desirable? Remember that in even-aged management, we seldom want reproduction until the time of final harvest. However, in managing hardwood stands under the selection system to be discussed, we need trees of all ages in our stand, and reproduction of good species is valuable.

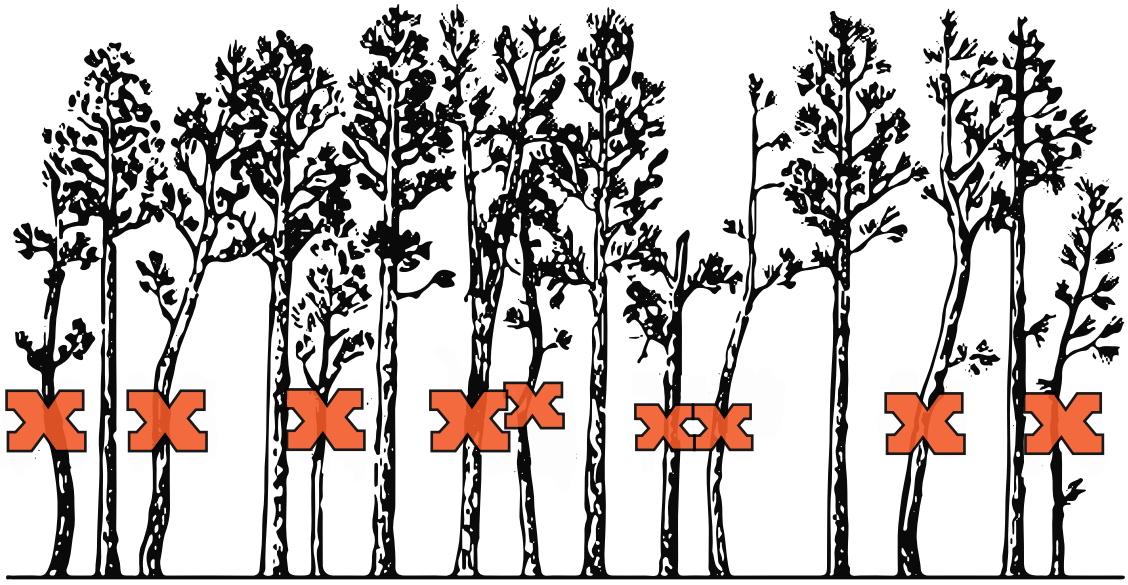
After obtaining all necessary information, we are now in a position to make a decision as to the best management practices to apply to our timber. Our next step is to understand these practices thoroughly.

Intermediate cuttings

Intermediate cuttings are those made in an immature stand. Each type of intermediate cutting is designed to meet specific forest needs. However, in actual practice, most cuttings result in accomplishing several objectives and therefore are combinations of the different types.

Thinning: Thinning an immature stand to maintain or improve growth rate is usually applied in even-aged stands. During early years in natural and planted stands, there are always many more trees present than can grow to maturity, due to competition for growing space, nutrients, and moisture.

- If possible, thinning should be done early enough in the life of a stand to prevent the usual loss of growth that occurs as a result of intense competition.
- Young, even-aged stands may need thinning when 15 years old, or possibly at an earlier age on good growing sites.
- Due to its cost, thinning is usually delayed until the trees to be cut will produce products suitable for sale, such as pulpwood or posts.
- A thinning should be planned when the following conditions exist:
  - ◊ Tops or crowns are interlaced or touching.
  - ◊ The length of the live crown is less than 30 to 40 percent of the total height of the trees.
  - ◊ There are many dead or dying trees present in the stand.
  - ◊ Trees that have excessive limbs or are crooked, diseased, or injured should be removed.
- In clusters or groups of good trees, sometimes the removal of two or three trees from the center will result in freeing the remaining crowns, although spacing may not be ideal.
- Properly planned thinnings in a timber stand make timber production more attractive economically and provide periodic income.
- Regular thinnings in a stand tend to put growth on selected trees. This means that trees of the highest quality will be produced and, consequently, greater returns per acre will result.



Removing crooked, excessive limbs, diseased, forked, and suppressed trees provides growing space for quality trees.

Other improvement cutting

Cuttings other than for final harvest are made during the life of a stand for the purpose of improving its composition or condition.

- **Release cutting:** This practice frees trees from harmful competition by felling, girdling, or poisoning inferior trees and is usually applied to young stands. For example, release cutting is used in pine stands to remove or kill overtopping or competing inferior hardwoods, permitting free growth of young pines. It is used in hardwood stands to free good, valuable hardwood trees from injurious effects of overtopping or competing low-value hardwoods.
- **Salvage cutting:** These cuttings are made to remove dead, badly injured, or suppressed trees to use material suitable for sale before it becomes worthless. For example, salvage cutting may be applied to pines damaged by red heart rot or to hardwoods with bad fire scars.
- **Sanitation cutting:** These cuttings are made to remove trees killed or injured by fire, disease, or insects to prevent the spread of the disease or insect attack. For example, trees are cut to prevent the spread of oak wilt or Dutch elm disease, or to prevent new broods of pine beetles from spreading damage after pines have been attacked.

Harvest cutting

Harvest cutting is for the removal of mature trees.

Uneven-aged stands

Selection cutting consists of the removal of mature timber, usually the oldest or largest trees, either singly or in small groups at relatively short intervals, repeated indefinitely. The openings made during each cutting must be large enough to permit reproduction of acceptable tree species if an uneven-aged forest is to be maintained.

- This method has been used chiefly in hardwood stands, since it was believed that hardwood tree species were able to grow satisfactorily in the partial shade of the relatively small openings created by this system of cutting. Recent research shows that stands resulting from a series of cuts have not met expectations from the standpoint of composition or quality. Present economic and market conditions should be carefully considered before deciding to apply this type of cutting. The method is not suitable for intolerant trees. (Refer to the growth tolerance table in Lesson 4).
- To apply this method, the forest manager looks over each tree to decide whether it should be cut or left to grow. Usually, some improvement cutting is done at the same time to remove defective or diseased trees. Trees to be cut are those past their best growing period or those which will bring the greatest return.
- The primary advantage of this method is that it allows a cash return every few years, and this is often desirable for small ownerships. This advantage is often limited by a lack of markets to handle small amounts of material.

Even-aged stands

Caution: The practice of cutting even-aged stands to a diameter limit, which really amounts to cutting the largest and best trees, is most unsound. It leads to complete degeneration of the stand, since the trees that are left are not the younger trees but the trees that have been losing out in the struggle. In timber that has reached sawtimber age and sizes, most of these smaller trees have gone beyond the point where they can recover and put on satisfactory growth. Uninformed owners repeatedly make this mistake.

Clear-cutting

This method consists of removing the entire stand in one cut. Using this method, reproduction is secured in one of two ways:

- Planting of tree seedlings or direct seeding of the area following cutting assures new growth.
- Natural reproduction is obtained by seeding from trees cut in the clearing operation. This is chiefly of value in pine stands. To be reasonably sure of success, the stand should be cut in a good seed year, during or immediately following seed fall. In hardwood stands, reproduction is often secured as a result of stump sprouting and from underground rootstocks.

Clear-cutting in strips or blocks

In this method, the stand is divided into a series of strips or blocks; one area is cut and the next is left uncut.

- Reproduction is secured by seed from the adjoining uncut areas. After reproduction is secured, the uncut areas are then harvested and reproduction is secured as in routine clear-cutting. There are many variations of this system, and competent advice should be obtained so that the plan may be tailored to the particular conditions.
- One advantage of this method is that it permits the income from timber to be spread over a period of years. However, it would be of doubtful value for species other than pine.

NOTE: Virginia's Seed Tree Law must be followed when clear-cutting pine stands, unless the landowner has a written management plan specifying other methods of reforestation.

Seed tree cutting

This practice removes the timber stand in one cut, except for selected seed trees properly spaced to reseed the area.

- The Virginia Seed Tree Law requires that in any cutting of pine (loblolly, short leaf, pond, or white pine) timber, at least eight cone-bearing pines with a minimum stump diameter of 14 inches must be left uncut on each acre. Complete details of this law should be understood before cutting has begun.
- Trees, like farm animals, should come from the best parents; therefore, seed trees should be selected with care and should be among the best trees of the stand.
- Seed trees should be removed after reproduction is well established and before young trees become too large. According to Virginia law, seed trees must remain standing for three years.
- The advantage of this method is that timber can be harvested and reproduction secured without additional effort or expenditure by the owner, providing all conditions are favorable. It should be thoroughly understood that simply leaving eight seed trees will not ensure reproduction. The soil must be well disturbed, hardwood brush must be eliminated, and cutting must be done in a good seed year during the fall and winter months. Unless these conditions are met, a satisfactory young stand is unlikely. As a result, many timberland owners secure prior approval of a reforestation plan which allows the seed trees to be cut, and the stumpage value they represent may then be used to replant the area with desired tree species.

Shelterwood cutting

This method removes the timber stand by a series of partial cuts that extend over a period of years.

- Usually this is accomplished in three separate cuts. The first cut removes undesirable trees, prepares a seed bed, and releases selected seed trees. The second cut removes enough of the stand to permit reproduction to become established. The third cut, which takes place about ten years after the first, removes the remainder of the stand.
- The advantage of this method is that there is a plentiful seed source from which to secure reproduction, and the income from the timber is received over a period of years.
- This method has been used with good results under certain specific conditions. In Virginia, it should be used only after careful consideration, for the light requirements (tolerance) of major pine species and also of many better hardwood species are such that the method produces unsatisfactory growth.

Lesson

6

ADDITIONAL ACTIVITIES

- Discuss stand analysis factors and review procedures for determining the forest type and ages of trees.
- Have students analyze and discuss the local forest situation—the percentage of privately owned vs. government- or industry-owned forest land, common forest types, even-aged and uneven-aged stands, the most profitable trees and tree products, harvesting practices, and disposition of low-value trees.
- Discuss types and advantages of intermediate cutting.
- Explain the methods of harvesting even-aged and uneven-aged stands. Emphasize the disadvantages of cutting even-aged stands to a diameter limit.
- Discuss the provisions of Virginia's Seed Tree Law.
- Discuss the various types of clear-cutting of even-aged stands and how reproduction is secured with each type of cut.
- Explain the circumstances under which shelterwood cutting is advantageous, and why it is not used to a great extent in Virginia.
- Conduct field observations to illustrate stand analyses, intermediate cutting, and harvest cutting.

SUGGESTIONS FOR STUDENT EVALUATION

- Students may take a written test on definitions and objectives of various cutting methods.
- Students may participate in a planting project.

SUGGESTED RESOURCES

Lotti, Thomas. Growing Loblolly Pine in the South Atlantic States: *USDA Farmer's Bulletin 2097*. Washington: U.S. Department of Agriculture, February 1956. http://digital.library.unt.edu/ark:/67531/metadc6268/m1/

Putnam, John A., Furnival, George M., and McKnight, J.S. *Management and Inventory of Southern Hardwoods: USDA Agriculture Handbook 181*. Washington: U.S. Department of Agriculture, 1960. http://naldc.nal.usda.gov/download/CAT87209126/PDF

Roach, Benjamin A., and Gingrich, Samuel F. *Even-Aged Silviculture for Upland Central Hardwoods: USDA Forest Service Agriculture Handbook 355*. Washington: U.S. Department of Agriculture, 1968. http://www.fs.fed.us/ne/newtown_square/publications/information_bulletins/pdfs/ah355.pdf

Virginia's Forestry Laws and Regulations: http://dof.virginia.gov/laws/index.htm

Lesson

6

TEACHER NOTES

Lesson

7

SOL CORRELATIONS

Biology
BIO.5
BIO.8
BIO.9

Earth Science
ES.7

English
9.1
9.5
9.6
10.1
11.5
12.1
12.5

EQUIPMENT, SUPPLIES, AND MATERIALS

- Instructor-provided forest management guidelines
- Seedlings and seed
- Hand-seeding machine

Reproducing the Forest

TEACHER: _____

SCHOOL: _____

GRADE LEVEL: 9–12

TASKS/COMPETENCIES

- Plant forest seedlings.
- Describe methods of forest regeneration.
- Identify tree care practices (e.g., TSI, release spray, tree shelters) in immature forests.

OBJECTIVES AND GOALS

- The student should be able to list and describe the methods of site preparation for tree reproduction.
- The student should be able to list and describe natural methods of tree reproduction.
- The student should be able to identify the advantages and disadvantages of natural methods of tree reproduction.
- The student should be able to explain factors that affect the quality of the seed source.
- The student should be able to list and describe the artificial methods of tree reproduction.
- The student should be able to explain the purpose of Virginia's Seed Tree Law.

Lesson

7

ACTIVITIES

► Preparation

Lesson approach

- One of the keys to continuing success in forest management is the ability to reproduce desirable forest stands when needed.
- Many ingenious schemes are found in nature to accomplish reproduction of the various tree species; however, the low-value species will often reproduce most efficiently and successfully.
- It is sometimes necessary to apply certain techniques to assist or guide natural reproduction.
- Often it is impossible to secure desirable tree reproduction naturally; in this case, direct seeding or planting is used to begin a new stand.

General situation

As of late 2013:

- There are more than a half-million acres of idle agricultural land in Virginia.
- There are approximately a half-million acres within the commercial forest areas that are non-stocked and can be planted without site preparation.
- There are several million acres of forest land that are poorly stocked and need to be planted following site preparation.

Local situation

The instructor should determine local practices relative to renewing the forest, establishing forest on land previously used for another purpose, and removing undesirable trees and brush from the forest area.

► Application

- Arrange to have students observe site preparation methods.
- Have students examine an area that has been reforested, and interview the owner to determine how the reforesting was done and what results are expected.
- Arrange to have students visit a nursery or seed orchard.
- Have students participate in the planting of seeds or seedlings at selected sites.

► *Presentation: Forest Reproduction*

Site preparation

Regeneration or reproduction of forest trees is accomplished naturally in many ways. Edible fruits and nuts are distributed by animals and birds. Papery wings and silken parachute attachments carry seeds in the wind, while hook devices fasten to fur or clothes for transport. Most of these methods are effective, as long as the spot where the seed lands is favorable for the germination and growth of the particular tree species involved.

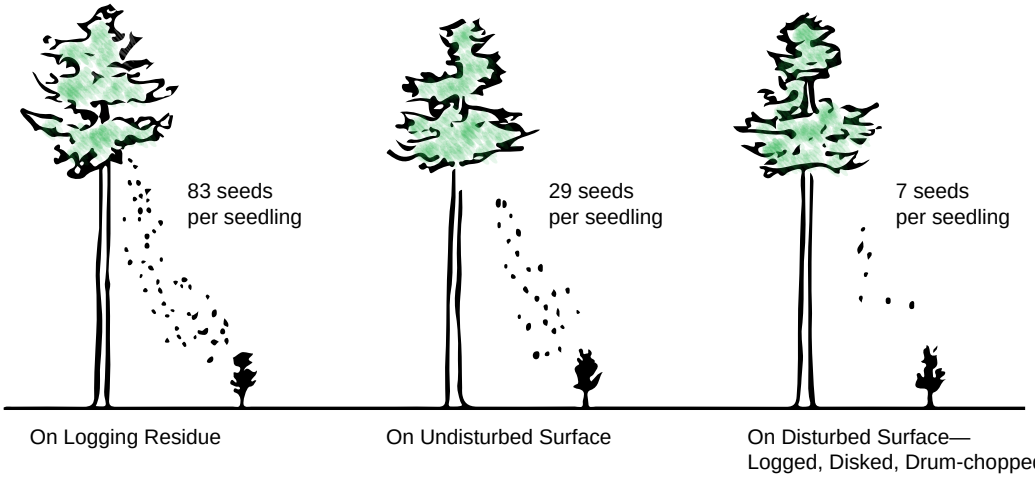
As we learned in Lesson 4, these specific site requirements are often quite complex, but since they undoubtedly determine the success or failure of this vital phase of our efforts to manage the forest, we must understand at least the basic requirements of the more valuable tree species. This knowledge can then be used to make certain that conditions in our stand are suitable for the reproduction on the tree species we desire to establish.

Methods

Most hardwood forests reproduce quite abundantly and with a wide variety of species, if protected from grazing and fire. Numerous hardwood species are able to reproduce by sprouting from stumps and underground rootstocks, as well as from seed. Therefore, site preparation measures usually are limited to making certain that the openings in the forest stand are large enough to ensure sufficient light for growth of high-value species. For example, yellow poplar must have full sunlight and exposed mineral soil to germinate and develop.

Since pure pine stands are not naturally a part of the permanent forest types in Virginia, and since they reproduce successfully only under favorable conditions, it is often necessary to use certain methods of site preparation, described as follows, to create these conditions. Occasionally, these same methods are suitable for use with some high-value hardwood stands.

Number of Seeds Needed to Establish One Pine Seedling on Different Classes of Seedbed



Drum chopping: In this operation, an implement known as a rolling drum chopper is pulled through the cut-over area by a large crawler tractor. The chopper consists of a heavy metal cylinder with large knives attached at intervals. The tractor and cylinder mash and flatten unwanted weed trees to the ground, while the knives serve to cut and tear the tree stems and to expose mineral soil. Under certain conditions this operation may be sufficient to create a satisfactory site for planting or seeding without additional treatment. Usually, however, it is necessary to follow drum chopping with prescribed burning after an interval, to allow the leaves and woody fuel to dry. This equipment has, to a large extent, replaced the use of a disk on recently logged areas and also on areas occupied by sprouts and small trees of unwanted tree species.

Disking: This involves pulling a large, heavy, disk-type harrow through the woodland either before or after cutting. This usually accomplishes two purposes: first, the destruction of the unwanted hardwood

undergrowth, and second, the disturbance of the forest floor to expose mineral soil and encourage germination of desired seed. If done prior to cutting, disking creates a favorable seedbed for all the seed from the stand and normally gives assurance of abundant reproduction. If the disking follows cutting operations, it is considerably less efficient due to stumps, tops, and lesser amounts of seed; nevertheless, if an ample seed source is available, reproduction is usually secured. The most advantageous time to disk is from midsummer to the time of seed fall, but it has been found effective when applied in almost any season.

Bulldozing: In this method a medium to heavy crawler-type tractor is used with a straight or toothed-type blade to scrape off the upper layer of the forest floor. This eliminates the undesirable hardwood undergrowth and also exposes mineral soil. Usually bulldozing is done after logging to reclaim or to convert areas to pine that have been invaded by unwanted hardwoods. Material pushed up is dumped in scattered piles or in windrows and is left to decompose naturally.

Some advantages of bulldozing over disking are immediately apparent. It more completely eliminates the hardwood brush and exposes a larger percentage of mineral soil, thus creating a longer-lasting seedbed. However, it has some serious disadvantages in that a certain amount of topsoil is unavoidably removed, and the soil conditions therefore become less favorable. The method is unsuited to areas subject to any considerable erosion, and in addition, it is more time-consuming and consequently more costly than disking. It is definitely unsuited to heavy-type soils that are compacted by heavy equipment.

Prescribed burning: The use of carefully controlled fire to prepare a site for planting or direct seeding has become an accepted practice in Virginia. Used by itself or with drum chopping or chemical spraying, fire has proved to be an effective and economically practical method for eliminating logging debris and reducing weed/tree species competition. There are certain factors involved with the use of fire that must be understood before finally deciding on its use. Fuel conditions and weather factors can determine the success or failure of any burning effort. Plans for control and assessment of the risks involved should be thoroughly considered. Seeking professional recommendations and guidance is strongly urged. Fire can be effective and comparatively economical, if wisely used, or completely ineffectual and extremely expensive if used without planning.

Use of tree poisons (silvicides): The primary use of chemicals is to kill the unwanted vegetation so that desirable trees have room to grow. There are several good silvicides on the market, and more are being developed and tested. Because of new developments in the chemical field, it is not practical to list the currently accepted silvicides. Up-to-date information should be obtained from local professionals.

Silvicides must be used according to the directions on the label. Improper use can cause damage to the environment and the person using the chemical.

Girdling: This is effective on most trees 12 inches in diameter and larger. Girdling is accomplished by cutting a band 3 to 6 inches wide entirely around the tree, making certain that the ax cuts sever the cambium and penetrate well into the wood.

Seed source

It is an accepted fact in agricultural research that the quality of a seed directly determines the quality of the plant it will produce. Like the breeding of farm animals, the quality of an offspring depends upon the characteristics of both parents that produce it. These characteristics are inherited qualities that may result in good or bad tendencies. Trees and their offspring are governed by laws of inheritance.

It follows, then, that not only is an ample seed source important but more attention must be paid to the quality of tree seed if we are to improve our woodland. Certain information must be understood about tree seed if we expect to manage the forest properly.

Genetic considerations

Many characteristics of trees formerly believed to be the result of environment are now known to be the result of inheritance. These include height growth, number of limbs, size of limbs, and angle of branching. Certainly these qualities can be influenced by environment, but they are determined largely by the tendencies passed down from the previous generation. Virginia is among the leading states in putting this knowledge to practical use. Superior pine trees of four species (Eastern white, loblolly, shortleaf, and Virginia) have been used as parent stock to establish seed orchards. These "superior" trees have been selected for extremely desirable characteristics after a search of thousands of forest acres within the state. After these selected trees are culled to a limited number of the best specimens, small pieces of branches are removed and grafted to healthy rootstock. The resulting tree will produce seed at an early age, with inherent "superior" characteristics. These trees are systematically planted in a seed orchard from which superior seed is harvested. From such select seed are grown tree seedlings that have inherited superior genetic characteristics. These seedlings are sold to Virginia landowners for reforestation purposes. In this way, seed to restock our woodland comes from our best trees. We should spare no effort to select the best trees as seed trees to regenerate our forests.

Location of seed source

The geographic location of the source of tree seed we use is also important. If we rely on our own seed trees, then this consideration is of no concern, but purchase of tree seed collected from distant areas of the country or from drastically different climate areas is unwise. Research and testing show that survival and growth materially decrease if tree seeds originate in distant sections of dissimilar environment.

Frequency of good seed years

Most tree species vary markedly from year to year in the size of the seed crop produced. This knowledge and the ability to predict a good seed crop enables the forest manager to harvest timber during good seed years, or if economics force cutting in a poor seed year, the manager should be aware that other means to secure reproduction may be necessary.

Closely associated with the amount of seed produced are changes in quality of seed. The poorer the crop determines the smaller percentage of viable seeds that will germinate and grow. Thus, it is vital to know the seeding characteristics of the important trees. How often do good seed years occur? Are some seeds produced each year? What time of year do the seeds mature? What percent of germination can we normally expect? The forest manager must know these answers to generate the forest successfully.

Virginia's Seed Tree Law

To try to ensure a uniform source of seed to perpetuate reproduction of some of the more valuable timber-producing species, a seed law was enacted. Briefly, this law provides that any person cutting timberland on which loblolly, shortleaf, pond, or white pines compose more than 10 percent of the stand must leave uncut at least eight pines per acre measuring 14 inches or more in diameter. These provisions are only minimum measures, and often twice this number of trees, plus some site preparation measures, are needed to ensure adequate reproduction.

Since the objective of the Seed Tree Law is to procure prompt reforestation of cutover land, Section 10.1-1163 of the Code of Virginia permits a person not to leave seed trees, provided he or she secures the approval of the state forester for an effective reforestation plan to be carried out following cutting.

Natural methods of reproduction

In this category are listed the various processes by which a forest is renewed as a result of self-sown seeds. Here we use the seeds from trees already part of our forest to reproduce a similar forest.

For successful natural reproduction, three conditions must be achieved: (1) abundant seed supply; (2) favorable conditions for germination of seed; and (3) favorable conditions for the growth of young seedlings.

Method descriptions

Generally, in any reproduction method, two activities are involved: first, the removal or harvest of the timber stand, and second, its replacement with a new stand of young trees. There have been many of these methods developed, but most are variations of similar principles. In Virginia, we need only consider three such methods. (These cutting methods have been described at some length in Lesson 6.) Under any of the three methods, seed trees are selected in advance of cutting operations and marked with paint, rags, cards, or other identification.

Selection method: Since only selected trees are cut at any time, reproduction comes from seed produced by remaining trees in the stand or from stump sprouts. As previously noted in Lesson 6, reproduction and growth of young trees have proved satisfactory in most instances when this method is used.

Clear-cutting: Reproduction may come as a result of seed from all trees harvested if cutting is done during or immediately after seed fall. However, if this method fails to produce a satisfactory stand, then some form of artificial reproduction must be substituted.

Seed tree cutting: Under this system, reproduction depends on seed produced by trees reserved for this purpose during harvest cutting. The number of trees to leave varies with tree species, seed productivity, age of stand, and other factors but usually ranges from 8 to 12 trees per acre. Since immature trees usually bear only small quantities of poor-quality seed, it is important that seed trees selected be proven seed producers. Also, it is important that consideration be given to the genetic qualities of the trees selected. Care should be taken that seed trees are spaced uniformly over the cutting area to ensure uniform coverage.

Spacing Guide	
Trees Per Acre	Feet Between Trees
2	148
4	104
6	85
8	74
10	66
12	60
14	56
16	52

Advantages of natural methods of reproduction

- It is generally regarded as the least expensive system.
- The species is adapted to local climatic conditions.
- It is suited to low, wet areas where the use of heavy equipment is impractical.

Disadvantages of natural methods of reproduction

- Valuable time is perhaps lost securing new stand.
- Control of species reproduced is often difficult.
- Uniform stand is difficult to achieve.
- Reproduction results are variable, depending on the size of the seed crop, and the bird and rodent population.
- Reproduction is often too dense, with intense competition slowing growth.

Artificial methods of reproduction

Methods covered in this grouping are planting and direct seeding. Since these methods involve physical planting of either tree seedlings or tree seed, they also involve selecting the species to be used. It cannot be too strongly emphasized that this selection must be carefully made to ensure that the species is suitable for the environment in question and for the markets available. Securing the advice of a local forester or other expert competent to weigh the facts of the situation is strongly advised.

Planting

This has been the commonly accepted method for artificially renewing the forest. Thousands of acres of plantations in Virginia and most other states testify to the general success of the work.

Selection of planting stock: Loblolly and Eastern white pines have been the most successful species in Virginia. Loblolly, shortleaf, and Virginia pines are raised in one year at nurseries, while white pine is kept in the nursery for two years. Hardwoods are more demanding in the amount of planting care required and have generally been less successful in plantations.

Survival rate: With favorable weather and good planting procedures, survival rate should be at least 70 percent.

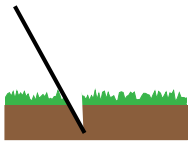
Season to plant: Best results are obtained during the dormant season when growth of seedlings is slowest. Depending on the weather, the best time to plant is from February 1 to April 15.

Tools used

- Various types of tractor-drawn tree-planting machines are available. Tree-planting machines are occasionally used when planting former pastures or croplands, but generally not on cutovers. These units are capable of planting approximately 1,000 seedlings per hour. The Virginia Department of Forestry has a limited number of machines that landowners can borrow.
- Hand shovels, mattocks, grubbing hoes, and planting bars can be used for planting. The planting bar has the widest acceptance, especially in the Piedmont and Tidewater sections of Virginia; it is often rather inexpensive and can be made in the school or farm workshop. (See Appendix A for a scale drawing of a planting bar.)

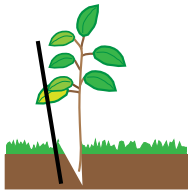
Care of planting stock: Bundles should be stored off the ground in a shady, cool (not freezing) location, with space around the bundles for ample air circulation.

Planting procedure: The seedlings purchased from the Department of Forestry are treated with kaolin clay. This material seals in the moisture and should not be washed off. During planting, the seedlings should be carried in a planting bag or container and the roots must not be exposed to the sun or drying winds.

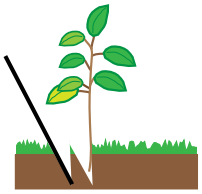


1. Insert bar at an angle and push upright.

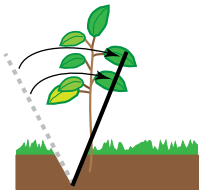
2. Remove bar and place seedling at the correct depth.



3. Insert the bar 2 inches from the seedling.



4. Pull the handle of the bar toward you, firming the soil at the bottom of the roots.



5. Push the handle of the bar forward to firm the soil at the top of the roots.

6. Fill in the last hole by tamping the soil with your heel.

7. Firm the soil around the seedling with your feet.

8. Test planting by pulling lightly on the seedling.

Spacing of trees: Currently, pines are planted at 400-600 trees per acre, depending on management goals. Recommendations will continue to change as more growht research is conducted and new mar-

kets (such as biomas) emerge..

Obtaining trees: Forest tree seedlings are available from nurseries operated by the Virginia Department of Forestry. Information about the purchase of trees can be obtained from chief forest wardens, a county forester, or the nearest district office.

Pales weevil damage prevention: Because of the likelihood of pales weevil damage, it is advisable to delay planting pine seedlings for one year in a cut-over pine woods, or purchase seedlings pre-treated with an insecticide. Further explanation is found in Lesson 11.

Lesson

7

ADDITIONAL ACTIVITIES

- Arrange for students to visit a forest site in need of regeneration. Discuss with students how the site might be prepared for reproduction and the various methods of regeneration that could be applied.
- Invite a professional forester to discuss regeneration techniques with the class.
- Arrange for students to visit selected nurseries or seed orchards.

SUGGESTIONS FOR STUDENT EVALUATION

- Students may take a written or oral test on explanation of tree regeneration methods.
- Students may participate in a planting project.

SUGGESTED RESOURCES

Forest Learn: http://www.forestlearn.org/flowhtm/flowcycl/forest/FORFRAME/FORTIMB/REFOR/REFORA/reforA.htm

Virginia Department of Forestry: http://www.dof.state.va.us/

Lesson

7

TEACHER NOTES

Lesson

8

SOL CORRELATIONS

English
11.6

Mathematics
A.1
A.4
A.7
G.13

Civics and Economics
CE.9

Science
ES.1

History and Social Science
GOVT.15

EQUIPMENT, SUPPLIES, AND MATERIALS

- Case study data or pulp sticks for measurement
- Instructor-provided checklist for market plan evaluation
- Steel tape measure
- Biltmore stick (with Merritt hypsometer)
- Tree calipers
- Samples of bids and contracts

Measuring and Marketing Forest Products

TEACHER: _____

SCHOOL: _____

GRADE LEVEL: 9–12

TASKS/COMPETENCIES

- Use various methods for measuring forest products (e.g., saw timber, carbon, chip and saw, pulpwood).
- Identify markets for forest products.
- Select timber for a hypothetical purchase.
- Calculate the total volume of saw timber or pulpwood, or both, on a given tract.
- Determine the value of standing timber.
- Develop a plan to deliver forest products to manufacturing sites.
- Demonstrate the proper use of common forestry tools and equipment.

OBJECTIVES AND GOALS

- The student should be able to define terminology associated with measurement of pulpwood and standing timber.
- The student should be able to identify and demonstrate the use of tools for measuring stacked and standing timber.
- The student should be able to perform mathematical computations used in the measurement of timber and demonstrate conversion to the desired measure.
- The student should be able to explain the process by which the volume of a tract of standing timber is estimated.
- The student should be able to identify markets available in the local area.
- The student should be able to explain the factors that influence the sale of wood products (what to sell, when to sell, and how to sell).
- The student should be able to identify and describe the common methods of marketing timber.
- The student should be able to identify the components of a written timber sale contract. The student should be able to identify and define the types of bids.
- The student should be able to identify logging byproducts that may be marketed.

Lesson

8

ACTIVITIES

► Preparation

Lesson approach

- The profitable growth and marketing of products depends on knowledge of the units of measurement used, how the measurements are obtained, and how they are best used in sales negotiations.
- Cordwood is sold using the 128-cubic-foot "standard cords" and by weight.
- Sawtimber is sold in units of 1,000 board feet, estimated by different log rules, by mill run, by the boundary, and by the weight.
- Timber may be sold at auction, by sealed bid, negotiated, and by percentage of harvest.
- A written contract should be drawn up for each sale and should state the terms of the sale and any limitations on the buyer.
- Landowners are encouraged to use a forest consultant or other professional when selling timber or managing forests.

General situation

- Many forest landowners sell forest products without knowing the value or quantity of the product.
- Units of measurement may be misunderstood.
- The terms of a timber sale are often discussed verbally and no written agreement is made.
- Boundaries are not always clearly marked, and selling timber by the boundary may result in litigation.

Local situation

- Determine whether any students have timber of saleable size on their property; if so, determine whether it is sold and for what products, and how it is measured or estimated.
- Determine whether students are familiar with the units of measurement used in marketing products (e.g., pulpwood, piling, poles, sawtimber, and fence posts).

► Application

- Have each student practice measuring timber using a Biltmore stick.
- Optional activity: Make a Biltmore stick.
- Arrange for students to visit a site where each student participates in the step-by-step operation of measuring and estimating timber.
- Select one group of trees sized for sawtimber and one sized for pulpwood. Have students estimate the volume.
- Arrange for students to visit a wood-using industry such as a pulp company, pellet plant, biomass facility, or sawmill, so students can observe raw materials being converted into usable products. Have them observe the actual volume cut from a log measured before sawing.
- Have students develop a marketing plan for a given forest tract.

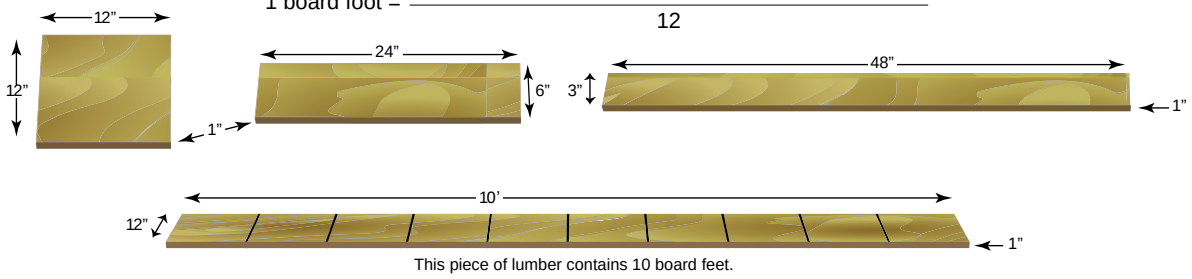
► *Presentation: Measurements and Markets*

Defining units of measurement

- **Log:** a section of the trunk of a tree, usually a minimum of 8 feet in length with a minimum diameter of 6 inches, inside the bark, at the small end.
- **Pulpwood, biomass fuel, or cabin logs:** a section of the trunk or larger limbs of a tree 5 feet in length, with a minimum diameter of 4 inches, inside the bark, at the small end.
- **Board foot:** unit of measure for lumber; equivalent to a board 1 inch thick and 12 inches square. A board 1 inch thick, 12 inches wide, and 10 feet long contains 10 board feet.

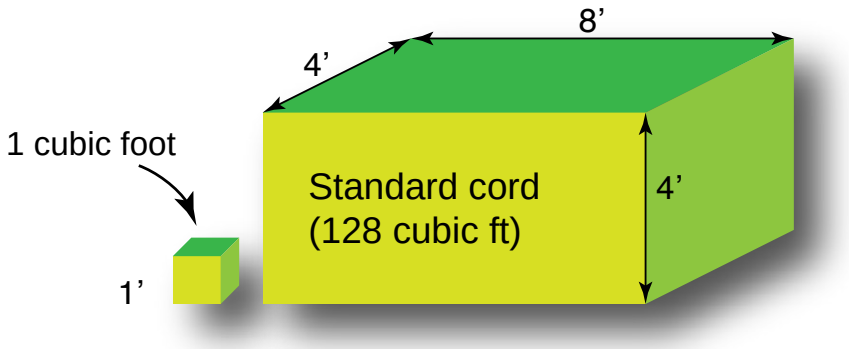
Each piece of lumber contains 1 board foot.

$$\text{1 board foot} = \frac{\text{thickness (inches) x width (inches) x height (inches)}}{12}$$



This piece of lumber contains 10 board feet.

- **Cubic foot:** unit of measure 12 inches wide, 12 inches thick, and 12 inches long, or its equivalent, used to measure cord wood volume.



- **Standard cord:** contains 128 cubic feet of unpeeled, stacked wood. This is a stack of wood 4 feet wide, 4 feet high and 8 feet long.
- **Piece:** poles and pilings that are valuable special products. Standards of length, straightness, and diameter determine value. Different standards apply to posts and crossties, but dimensions and quality determine value.
- **Weight:** Most pulp companies buy pulpwood by weight instead of by the cord and unit. The weight used to represent a cord may vary between companies but will be the average weight per cord determined by measuring and weighing many loads of wood in their particular area.

Lesson

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Using log rules

A log rule is a table showing the estimated or calculated amount of lumber that can be sawed from logs of a given length and diameter. These rules are based on different formulas, or are derived in different ways, so that they do not agree as to the amount of lumber that can be sawed from a log of a given size. The most commonly used log rules are as follows:

- International ¼-inch rule—the most accurate of the log rules, recommended for use in the commonwealth of Virginia.
- Doyle Rule—underestimates small logs.
- Scribner Decimal C Rule—an official rule of the U.S. Forest Service.

Comparison Table of Log Rules

Log Length Feet	Diameter of Log, Top End (Inches)								
	10”			2”			3”		
	Int.	Doyle	Scribner	Int.	Doyle	Scribner	Int.	Doyle	Scribner
12	45	27	30	210	192	210	495	507	490
14	55	32	40	250	221	240	585	591	570
16	65	36	50	290	256	280	675	676	650
18	75	41	60	330	288	310	765	761	740

Measuring logs

- Pine and hardwood sawlogs are cut to the nearest even foot (e.g., 8-, 10-, 12-, 14-, 16-foot logs), allowing an extra 2 to 4 inches for trimming. Use the following procedure in measuring logs:
  - ◊ Measure the average diameter of the small end of the log in inches, inside the bark. Take at least two measurements to compute the average diameter.
  - ◊ Measure the length of the log to the nearest even foot. Drop all fractions, but allow 2 to 4 inches for trimming. For instance, a log measuring 9 feet 10 inches would be an 8-foot log.
  - ◊ Deductions must be considered for crook, decay, or other defects. This can usually be handled by adjusting the scaling diameter.
  - ◊ Use Virginia Department of Forestry Publication No. 58, *Tables for Measuring Timber* (see Appendix B), to determine the volume in the log from the Log Scale. For example, the volume of the log described above would be 115 board feet.

Log Scale International Rule ¼-inch Kerf

Diameter of Log Small End (inches)	Length of Log (Feet)				
	8	10	12	14	16
	Volume in Board Feet				
8	18	22	25	35	40
9	22	30	35	45	50
10	30	35	45	55	65
11	35	45	55	70	80
12	45	55	70	85	95
13	55	70	85	100	115
14	65	80	100	115	135
15	75	95	115	135	160

- The total volume is computed by multiplying the number of logs in each size class by the board feet in one log of that size. Thus, 4 logs, 9 inches dib (diameter inside bark at small end) and 8 feet long contain 22 (board feet in one log) x 4 logs of this size = 88 board feet.

Lesson

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Estimating standing timber (board feet)

It is somewhat more difficult to estimate the volume in a standing tree than in a log. A number of tools may be used, but a Biltmore stick is all that is necessary.

The Biltmore stick

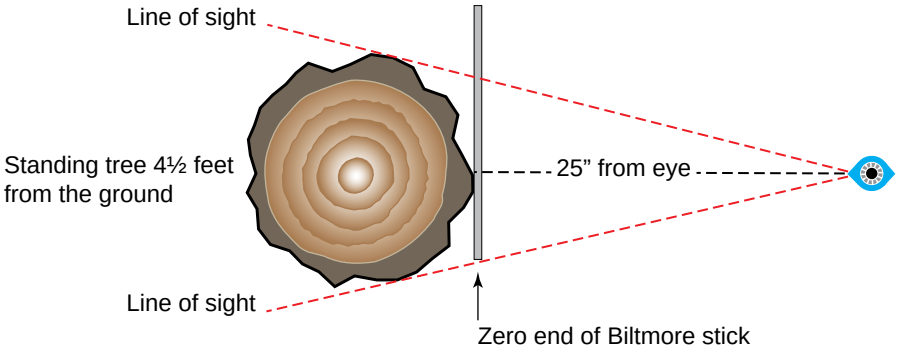
This measuring device has three graduated sides that are used to measure diameter and height. The fourth side is the Scribner Decimal C Log Rule, which will not be used.

- Biltmore stick side is used to measure diameter at breast height, which is 4½ feet from the ground.
- Merritt hypsometer side is used to determine merchantable height in terms of 16-foot logs.
- Yardstick side is used to measure small end of logs for diameter and/or the length of the log.

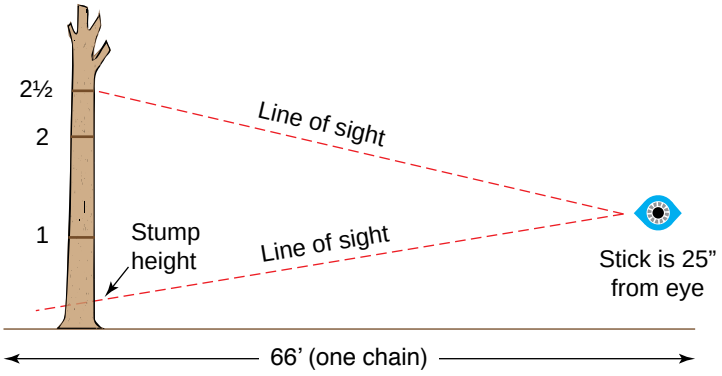
Standing tree volume determination

To determine the volume of a standing tree, two measurements must be determined. The first is the diameter at breast height, and the second is the merchantable height of the tree to the nearest one-half log. Merchantable height is usually up to a 6-inch top diameter for pine and an 8-inch diameter for hardwood. A log is 16 feet long, and one-half log is 8 feet long.

- To measure diameter, hold the Biltmore stick horizontally, 25 inches from the eye. With the stick against the tree, 4½ feet above the ground, line up the left end of stick with the outer edge of the bark. Without moving anything but the eyes, read the nearest graduation on the stick to the other edge of the tree. Take another reading at right angles to this first reading. Average the two readings. This is the diameter of the tree. If one reading is 13 inches and the other 15 inches, the diameter is 14 inches.



- To measure the merchantable height, use the Merritt hypsometer side of the stick. Pace or step one chain (66 feet) from the tree. Face the tree and hold the stick perpendicular to the ground, 25 inches from the eye. Line up the bottom of the stick with the approximate stump height. Moving only the eyes, read the merchantable height to the nearest one-half log (8 feet). A tree having 2½ logs of merchantable height would have 40 feet of merchantable length.



- To determine volume, refer to *Tables for Measuring Timber*, Virginia Department of Forestry Publication No. 58. Use the table headed "Tree Scale in Board Feet" (see Appendix B).

Under the column headed "Diameter at Breast Height," locate the diameter of the tree to the nearest 2-inch class. Move the finger to the right under the column giving the proper tree height in logs. The figure at the intersection of these two lines of figures is the board foot volume the tree contains.

For example, if the tree is 14 inches in diameter and contains 2½ logs, the volume is 160 board feet.

Tree Scale in Board Feet

Diameter at Breast Height (inches)	Number of 16-foot Logs								
	1	1½	2	2½	3	3½	4	4½	5
8	20	27	33	38					
10	38	50	61	69	77				
12	56	77	96	110	124	132	143		
14	82	110	138	160	182	196	211		
16	108	146	183	214	246	269	292		
18	140	190	240	282	325	356	388		
20	176	240	305	360	414	455	496	528	561
22	216	297	378	446	514	568	621	666	710
24	260	359	458	543	628	690	753	814	875
26	305	422	540	641	742	820	899	972	1,046
28	357	496	635	756	877	969	1,061	1,152	1,242
30	413	575	737	878	1,020	1,128	1,235	1,346	1,458
32	474	661	848	1,014	1,181	1,310	1,440	1,562	1,685
34	538	752	966	1,158	1,349	1,498	1,647	1,790	1,932
36	602	844	1,087	1,304	1,521	1,690	1,860	2,024	2,189
38	674	947	1,220	1,470	1,720	1,910	2,101	2,294	2,488

Estimating standing timber (cubic feet)

To estimate the number of cubic feet in a standing tree, follow same procedure as in estimating for board feet.

- Determine the diameter at breast height (dbh) using the Biltmore stick. Determine merchantable height to a 4-inch top in terms of l6-foot logs and convert to 5-foot bolts. (If a tree contains two logs to a 4-inch top, this equals 32 feet or six 5-foot bolts to the nearest bolt.)

- Refer to the last page of Virginia Department of Forestry Publication No. 8, to the table headed "Tree Scale for Pulpwood." This will give the volume in cubic feet, including the bark. Use table as is for sawtimber, except that the answer is in cubic feet. If dbh is 8 inches and tree contains eight 5-foot bolts, it has 8.93 cubic feet. After determining the total cubic foot volume of a group of trees, remember to divide the total cubic feet by 90 to convert cubic feet to *standard cords* (128 cubic feet of stacked wood, including bark, contains approximately 90 cubic feet of solid wood).

Determining products to be sold

To determine whether a forest site contains saleable products, it is essential to know the types of products for which there is a demand and the comparative values involved.

Value

Available markets determine value. Markets vary from one locality to another, and consequently the local market situation must be carefully checked.

Products (types of markets)

This list covers the more common markets available. However, it is seldom that all of these would be

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available in any one area of the state.

sawlogs	pulpwood
crossties	veneer
posts	piling
mine	timbers
poles	handle
stock	cooperage
fuelwood	biomass

engineered wood products

Selecting the market

What to sell

Products vary materially in their value, and trees should be sold in the product that will yield the best return. Sawlogs will bring more per unit of volume than will smaller products such as pulpwood or fuel wood. Large sawlogs, veneer bolts, pilings, and poles will bring higher returns than the average sawlog.

As an example, the following tables illustrate comparative values for pine timber between the International ¼-inch Log Rule, the Doyle Log Rule, and pulpwood.

The first column of each table represents the tree size (diameter and merchantable height). Table A represents the board foot volume for the International ¼-inch Log Rule, and using stumpage values between $50 per MBF (thousand board feet) and $100 per MBF gives the dollar value of the tree. Table B shows the tree value using the Doyle volume tables. Table C shows the standard cord (cubic feet converted to cords) content of the tree and its value at $8 and $12 stumpage.

These tables emphasize the difference in the Doyle and International volume tables, as well as the monetary difference in selling quality-size sawtimber as pulpwood.

COMPARISON OF AVERAGE TREE STUMPAGE VALUES

Table A—Value of Tree (Sawtimber) Using International ¼-Inch Rule

Tree Diameter & No. Logs	Board Foot Volume	Stumpage Value		
		$50.00	$75.00	$100.00
12” x 2 logs	92	4.60	6.90	9.20
16” x 3 logs	241	12.05	18.08	24.10
26” x 4 logs	877	43.85	65.78	87.70

Table B—Value of Tree (Sawtimber) Using Doyle Rule

Tree Diameter & No. Logs	Board Foot Volume	Stumpage Value		
		$50.00	$75.00	$100.00
12” x 2 logs	43	2.15	3.23	4.30
16” x 3 logs	149	7.45	11.18	14.90
26” x 4 logs	737	36.85	55.28	73.71

Table C—Value of Tree (Pulpwood)

Tree Diameter & No. Logs	Cords	Stumpage Value	
		$8.00	$12.00
12” x 2 logs	.17	1.36	2.04
16” x 3 logs	.41	3.28	4.92
26” x 4 logs	1.36	10.88	16.32

Lesson

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When to sell

The best time to sell any product is when the market for it is high. The timber market fluctuates, as do all markets, and the timberland owner has an advantage in that timber can be held on a low market and it will continue to add additional growth.

Quite often, farmers find it to their advantage to use the off-season labor to cut their own woodlands. This practice is good business for farmers, and quite often many products can be harvested and sold by the farmer that might otherwise be lost because a sufficient volume or quantity to interest a commercial cutter is lacking. Other timber owners (especially small-tract owners) should be made aware of these seasonal opportunities.

How to sell

The woodland owner has two ways to market forest products. They can be sold as standing trees, or they can be partially processed in such forms as sawlogs, pulpwood bolts and veneer bolts.

These products may be sold on the roadside or delivered to sawmills, construction yards, rail sidings, or other specified purchasing points.

Choosing method of marketing forest products

Most timber is sold as stumpage in standing trees. The buyer assumes the responsibility of logging the area, and the owner has no responsibilities except those reserved to him in his contract. These usually refer to supervision to ensure the protection of uncut trees, fences, soil and water resources, and existing roads. The timber may be sold in several ways:

Lump sum or boundary: The timber is sold on a designated area or on an acreage basis. The timber should always be cruised and an accurate estimate secured before the sale.

Mill run or tally: The owner receives payment for the timber actually processed, or the pulpwood cut. Care must be taken by the seller to prevent the operator from cutting only the best trees or best portions of the trees and leaving the remainder in the woods.

Diameter limit cutting: The minimum diameter limit of trees that may be cut is specified, such as all trees 10 inches in diameter, 10 inches above ground level. This is usually a poor cutting practice, since the poorest trees are left for future growth.

Marked basis: This is the best method when making partial cuts, as the best trees are left for future growth. Sawtimber is marked and estimated so that the seller knows how much volume is for sale. It is not necessary to estimate pulpwood, since the wood is always measured at the yard or mill.

Log scale: Logs are sold on the basis of board foot scale, measured after the trees are felled and cut into logs.

By the piece: Specialty products such as poles and piling are sold by the individual piece. The buyer designates these trees and the price is determined according to class or grade. Posts and crossties are also sold by the individual piece.

Using bids and contracts

Bids

Direct negotiation: The seller may contact several possible buyers and obtain their best offers, take the highest bid, and make the sale to that bidder.

Sealed bid: The sale is usually advertised in the local paper, requesting that bids be submitted by a given date and time. The bids are opened at this time, and the sale is made to the highest bidder. However, the right is usually reserved "to reject any or all bids," so that the seller is not forced to accept any bid that does not satisfy predetermined requirements.

Auction bid: The sale is advertised and scheduled for a given time and place. Interested buyers make

their bids and have the chance to raise them as others bid.

Contracts

Any time the buyer (or the buyer's agent) is to cut the sold timber, a written agreement should be drawn up. The price to be paid, the length of time allowed for removal of timber, and any penalty clauses should be specified and the contract should be properly signed and witnessed.

Suggestions for Timber Sale Contract Provisions

The following provisions should be considered by timber sellers and their attorneys when writing a contract.

Description of timber offered for sale

- Designate the acreage and definite boundaries of the timber area offered for sale.
- Stipulate which trees are to be cut. Describe the method of marking selected trees to be cut. State the volume of timber estimated in accepted units of measure.
- Where seed trees have been selected, describe how they are marked or designated and stipulate that care must be exercised to avoid damage.

Statement of agreed-upon purchase price and method of payment:

- Be certain that the method of payment is such that the buyer cannot cut the best trees and then move out. A lump-sum payment or partial payments in advance for designated cutting areas can prevent this.
- Make certain that the purchase price is agreed upon and explicitly stated.

Logging restrictions and guarantees

- Guarantee the purchaser a right of ingress and egress for workers, materials, and equipment.
- Stumps should not exceed 12 inches in height unless a defect at the butt requires a higher stump for safe felling. All trees must be felled inside the designated sale area.
- All trees not designated to be cut (in seed tree cutting, all marked trees are designated to be left) should be protected against unnecessary injury in felling, skidding, and hauling operations. Unnecessary cutting of young trees should be prohibited. Tops and logging debris should not be permitted to pile up around reserved trees or valuable young growth. These provisions are especially applicable for selection cutting, thinnings, and improvement cuts.
- If the area is to be clear-cut for even-aged management, provisions should be made to remove the majority of the standing timber to help replace the cost of site preparation treatments.
- Existing roads on the sale area should be kept in passable condition during the operation and left in the same condition when the logging is completed.
- The seller reserves the right to designate or approve the location of forest roads and skid trails to ensure adequate watershed protection. The seller also reserves the right to designate or approve access across cultivated fields, pastures, or other cleared lands. Skid roads and haul roads should be constructed according to best management practices guidelines.
- Any damage by the purchaser or agents of the purchaser to fences or other improvements of the seller shall be repaired or paid for by the purchaser.
- A time limit for the logging operation should be specified (usually two years or less, depending on the size of the sale area.)
- Provisions may be included that describe the construction and removal of necessary logging structures.
- Trees or logging debris cannot be deposited in stream channels or water courses. This is in violation of Section 62.1-194.2, Chapter 20, of the Virginia Code.

Fire protection and responsibility clause

- The mill operator should be required to comply with the fire laws governing the operation of mill seat and burning pit areas. Clean mill areas aid in fire prevention. (See Section 10.1-1144, Chapter 11, Title 10.1, Code of Virginia.)
- All fires that may be burning at the mill in any slab pile or other debris shall be completely extinguished whenever the mill is not in operation, and no fire will be permitted to burn in the sawdust pile.

- The purchaser should be required to immediately suppress any fires originating from negligence of the purchaser or agents. The purchaser will be liable for all damage to timber suitable for sale, standing or felled, young growth, or other property of the seller, which may be caused by such fires.
- The purchaser should agree to aid in the suppression of any wildfires occurring on the sale area.
- All provisions of Virginia's Seed Tree Law must be met. Reforestation plans in lieu of leaving required pine or poplar seed trees must be prepared, submitted, and approved by the state forester prior to cutting.

Penalty clause: The stumpage price for undesignated timber that is cut should be stated (usually twice the stumpage rate per MBF as indicated by the purchase price).

Assignment of contract: Usually, an agreement is reached not to reassign any portion of the contract without the written consent of the seller.

Arbitration: Consider the need for setting up an arbitration board, should a dispute arise. This usually consists of one person selected by the seller, one selected by the purchaser, and one selected jointly by those already appointed.

Marketing byproducts

Byproducts are wood residues left in the woods after a logging operation.

Slab wood: If not used by the operator, it may be marketed in two ways: it may be trucked to a chipper and sold, or it may be marketed as fuelwood. There is a good fuelwood market in many areas. Slabs may be sold in the woods, or the timber owner may cut the slabs in short lengths and sell the wood as fuel or to a stationary chipping operator.

Chips: The majority of the larger mill operators have portable debarkers and chippers. Slabs, edgings, and small or defective logs are chipped and the chips are sold to the pulp mills. Depending upon the area, both hardwood and pine chips are used.

Bark: Bark may be sold to people interested in using it as mulch or, in some cases, to a processor who markets ground bark mulch commercially.

Sawdust: Sawdust is used, in some processes, in the manufacture of charcoal. It is also being used for wood energy. Rotten sawdust makes excellent mulch and may be sold for this purpose. Both bark and sawdust may be sold to commercial nurseries.

Fuelwood: When chippers are used in conjunction with a harvesting operation, there is little wood residue. However, in normal logging projects quite a bit of material is left that can be sold for fuelwood.

Lesson

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ADDITIONAL ACTIVITIES

- Have students define key terms related to measuring and marketing forest products.
- Have students use tools for measuring lumber and standing trees, and use a measurement conversion chart.
- Have students use mathematical computations involved in timber measurement.
- Have students use a Biltmore stick to measure the merchantable height of standing timber.
- Have students discuss the types of forest products most in demand in the local area.
- Have students discuss the relative market value of various wood products.
- Have students discuss the ways standing timber and felled trees may be marketed.
- Have students display and discuss samples of bids and contracts.

SUGGESTIONS FOR STUDENT EVALUATION

- The student may determine, through calculations, the volume of pulpwood from dimensions, pulpwood sticks, or a standing tree (±5 percent of instructor's calculation).
- The student may determine through calculations the volume of standing timber on a given tract (±5 percent of instructor's calculations).
- The student may develop a marketing plan for a selected forest tract (acceptable according to instructor-provided checklist).

SUGGESTED RESOURCES

Marketing Specialty Forest Products (University of Minnesota): http://www.extension.umn.edu/distribution/naturalresources/DD7278.html

Sampling and Measuring Private Timber in the Private Woodland (University of Minnesota): http://www.extension.umn.edu/distribution/naturalresources/DD3025.html

U.S. Forest Service's Forest Products Laboratory: http://www.fpl.fs.fed.us/

Lesson

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TEACHER NOTES

Lesson

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SOL CORRELATIONS

Biology
BIO.8
BIO.9

Earth Science
ES.2
ES.7
ES.9

English
9.1
10.6
10.8
11.6
12.1
12.6

Civics and Economics
CE.9

Mathematics
A.4

EQUIPMENT, SUPPLIES, AND MATERIALS

- Chain saw
- Hammer
- Wedges
- Instructor-prepared vocabulary and worksheets
- Instructor-provided checklist for evaluating harvesting plans

Using Forestry Best Management Practices

TEACHER: _____

SCHOOL: _____

GRADE LEVEL: 9–12

TASKS/COMPETENCIES

- Explain the effects of forestry best management practices on watershed conditions.
- Identify laws pertaining to forestry and water quality.
- Outline the essential steps to a pre-harvest plan.
- Outline the essential steps to a post-harvest plan.
- Comply with federal, state, and local safety and legal requirements in the operation of all equipment and tools.
- Describe the advantages and disadvantages of forest-harvesting methods.
- Outline procedures for supervising the loading and unloading of logs.

OBJECTIVES AND GOALS

- The student should be able to list best management practices for
  - woodland access roads
  - forest harvesting
  - filter strips
  - site preparation, including those for prescribed burns, the use of mechanical equipment, and the use of herbicides
  - tree planting
  - the use of pesticides
  - revegetation of critical forest areas
  - forest recreation areas
  - wildfire control and reclamation.
- The student should be able to define terms associated with harvesting timber.
- The student should be able to pass a safety test on tools and equipment use.
- The student should be able to identify how to make a tree fall in a predetermined direction.
- The student should be able to state reasons for harvesting trees from noncommercial forestlands.
- The student should be able to describe the shortwood and longwood systems used in logging.
- The student should be able to identify factors that affect the cost of hauling logs.
- The student should be able to describe and identify advantages of total tree chipping.
- The student should be able to explain how to determine the bucking cuts for crooked logs.

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ACTIVITIES

► Preparation

Lesson approach

- Application of forestry best management practices reduces erosion and ensures that good water quality makes sense from several points of view:
    - ◊ To protect the environment
    - ◊ To protect economic investments
    - ◊ To maintain the balance of nature
    - ◊ To comply with legal standards
    - ◊ To ensure future benefits from the forest and watersheds
- Forestry best management practices are a common-sense approach to effective forest management.
- Forestry best management practices can be applied by individual forest landowners (on the average farm) as well as by commercial wood-using industries and by agencies administering public forestlands.

General situation

- Virginia is fortunate to have an adequate supply of water. This water comes from streams, springs, and wells, and most of it originates in the forested watersheds in the mountains and foothills.
- Due to land use, the water downstream from the watershed often is of poor quality.
- Poor water quality is a national problem. For this reason, the Federal Water Pollution Control Act of 1972 was passed, stating that all waters of the United States must be swimmable and fishable by 1983.
- To meet this goal, Virginia instituted a voluntary approach and developed a best management practices program in the areas of agriculture, forestry, mining, urban planning, hydrology, and groundwater.
- There are several forestry best management practices, some which apply to loggers and harvesting operations, and some which apply to landowners. However, all of these practices can be carried out by either. More information can be found in *Virginia's Forestry Best Management Practices for Water Quality*.

Local situation

- Identify logging operations in the local area and the best management practices used at these sites.
- Determine whether any students who live on farms with timber tracts have ever instituted any of these practices.

► Application

Arrange for students to visit to a timber tract and have them develop a plan for harvesting (e.g., laying out log roads and skid trails, locating filter strips, planning site preparation measures, planning for tree planting after the harvest).

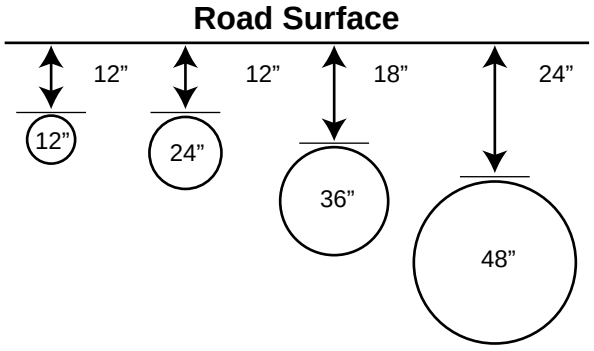
► *Presentation: Best Management Practices*

Forestry Best Management Practices for Loggers

Woodland access roads and skid trails

Roads and skid trails are necessary for any harvesting operation. A well-planned road and trail system reduces logging costs, reduces the amount of sediment getting into streams, improves landowner-logger relationships, and keeps streams in better condition for fishing and other uses.

- Locate roads on grades of 2 to 10 percent. A 10-percent grade equals a rise of 10 feet per 100 feet of horizontal distance. To allow for proper drainage, grades of 1 to 3 percent are preferred.
- Maintain grade by zigzagging up the hill instead of going straight up.
- Avoid wide, flat ridges for road location. Where possible, locate roads at the edge of a flat ridge for proper drainage.
- Locate roads away from streambeds.
- When crossing a stream, cross at right angles. Get in and out of the stream area as quickly as possible. Fords should not be used unless there is a hard, rocky bottom and the approaches are rocked to prevent mud holes and mud washing into the stream. If logs or heavy pallets are used to make a temporary crossing, they must be removed upon completion of the operation.
- Use a low-cost bridge if there are more than 200 acres above the crossing. On permanent roads, it is best to use culverts or bridges.
- Culverts must be covered with at least 12 inches of earth fill or one-half of culvert diameter, whichever is greater. Culverts must be long enough to extend the full width of road beyond fill. Slope a culvert 1 inch for every 4 feet of length for drainage.
- Make sure that water will drain off the road into undisturbed areas as quickly as possible. Crown the road and use side ditches.
- Outslope the road. This type of road may be hazardous in steep terrain. Level the shoulder on the downhill side.
- Inslope the road and use culverts to drain water to the downhill side. Use culvert tables to determine the size and frequency.
- Use water bars. Slant the water bar downgrade at approximately a 30-degree angle. This can be determined on a road 12 feet wide by having the lower end one big step (3 feet) lower than the uphill end. Make the bar 8 to 12 inches deep.



Size of Culverts Permanent Roads

Drainage Area Above Culvert	Coastal Plain	Piedmont	Mountains
acres	inches	inches	inches
10	12	18	21
20	15	24	24
30	21	24	30
40	24	30	36
50	30	36	42
60	36	36	42
70	36	42	48
80	42	42	48
90	42	48	54
100	42	48	54
150	48	54	60
200	48	54	66

Forest harvesting

- Plan the complete haul road and skid trail system before starting the cutting operation.
- Construct haul roads and skid trails.
- Leave filter strips between bodies of water and roads, skid trails, landings, and heavily cut areas.
- Remove all tops and laps from streams.
- Remove all trash (such as used oil and containers, hydraulic fluids, and filters) from the cut-

ting site.
- Locate landings and log decks on dry sites away from streams.
- Stabilize landings and log yards by seeding immediately after the cutting operation.
- In wetlands, plan the drainage system to fit natural drainages, obtain gradual initial discharge into waterways by the use of retention basins and cofferdams, and deposit the spoil far enough away from streams and ditches to prevent sloughing.

Filter strips

- Use filter strips to reduce the amount of soil entering the streams. When reserving a filter strip, consider the following factors:
  - Land use above the filter strip: bare ground equals a high erosion hazard.
  - Slope of land above the strip: the steeper the slope, the higher the erosion hazard.
  - Length of the slope: a long steep slope means a higher erosion hazard.
  - Erodibility of soil: clay and fine sand equal a higher erosion hazard.
  - Type of vegetation within the strip: dense vegetation means a lower erosion hazard.

Size of Filter

	Width in Feet Required		
Percent Slope	Slight Hazard	Moderate Hazard	Severe Hazard
0	30	40	50
10	55	75	90
20	80	100	130
30	105	140	170
40	130	170	210
50	155	200	250
60	180	235	290

- The following guidelines apply to filter strips.
  - Do not construct roads except when necessary to cross a stream. These crossings must be bridges of culverts with stabilized banks.
  - Do not remove more than 50 percent of the trees.
  - Do not use mechanical site preparation.
  - Do not use prescribed burning.
  - Do not use chemicals.

Forestry Best Management Practices for Landowners

Most of these practices can be carried out on the average woodlot.

Site preparation

This practice is in preparation for natural seeding or artificial regeneration (tree planting) and may be accomplished by any of the following methods:

- Using prescribed burns
  - Locate fire lines on contours and away from natural drainage.
  - Keep fire lines as shallow as possible but still effective.
  - Leave filter strips between fire lines and streams.
  - Turn fire lines into undisturbed areas; do not run them directly into streams. Complete the last 100 feet of line by hand.
  - Construct water bars to drain fire lines.
- Using mechanical equipment
  - Use mechanical equipment on the contour.
  - Use a site preparation method other than mechanical on slopes greater than 15 percent.
  - Use prescribed burning, light bulldozing, root raking, and shear blading in preference to straight blading; expose as little bare ground as possible.
  - Use a drum chopper where practical.
  - Leave filter strips between site-prepared areas and drainages.
- Using herbicides
  - Use herbicides *only* when this method is clearly the best prescription.

- Use only registered herbicides; read and follow the label carefully.
- Do not spray herbicides in or near streams.
- Do not wash or drain containers or spray equipment in streams.
- Dispose of herbicide containers properly.

Tree planting

The following guidelines are applicable when planting tree seedlings for any purpose:

- Plant by hand, if feasible.
- Minimize soil disturbance when using a tractor and V-blade with a wild-land tree planter.
- Plant on contour when using a mechanical tree planter.
- Use an herbicide-type planting machine in open-field areas on steep slopes.

Pesticide use

Follow these precautions when using chemicals to prevent damage by insects, diseases, mammals, or birds:

- Choose the correct pesticide and use according to directions on the label.
- Use the required safety equipment and clothing.
- Use pesticides only when weather and atmospheric conditions are favorable.
- Order no more than one year's supply of pesticide at any one time.
- Dispose of excess pesticide according to label directions.
- Follow the label directions for container disposal.
- If a container is to be washed, rinse three times and allow it to drain in a vertical position for 30 seconds between rinses.
- Check the label for burning instructions.

Revegetation of critical forest areas

This practice is to establish a quick vegetative cover on bare areas that are subject to erosion and are likely to become a sediment source area.

- Prepare the seedbed properly by smoothing, disking, and raking.
- Apply 2 tons of lime and 400 pounds of 10-10-10 fertilizer per acre.
- Select a seeding mixture from those listed in the seeding table.
- Use mulch on highly erodible soils.
- Protect the site from grazing and unauthorized traffic.

Seeding Table

Mixtures	Seeding Mixture Pounds/Acre
Kentucky 31 Tall Fescue	60
Kentucky 31 Tall Fescue Weeping Love Grass	60 2
Kentucky 31 Tall Fescue	40
Sericea Lespedeza	20
Orchard Grass	30
Game food mixture may be substituted	

Forest recreation areas

When forestland is used for recreational purposes, follow these guidelines:

- Construct roads to specifications as outlined in *Virginia's Forestry Best Management Practices for Water Quality: Fifth Edition*, page 26.
- Install drainages on foot trails (water bars or turnouts).
- Reinforce heavily used trails with gravel at critical points.
- Retain filter strips between parking areas and the water's edge.
- Restrict parking to designated parking areas.
- Drain parking areas adequately.
- Reinforce boat ramps to a depth of 30 inches below the low-water level with gravel or other non-washing material.
- Provide a water diversion device between boat ramps and their approaches.
- Provide sanitary facilities where use is concentrated.

Wildfire control and reclamation

Follow these guidelines when controlling wildfires and when reclaiming burned areas:

- Keep fire lines off steep slopes, if practical.

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- Avoid drainages when constructing fire control lines.
- Install water turnouts and drainage ditches on fire-control lines once a fire is brought under control.
- Use hand tools to construct the last 100 feet of fire-control line before reaching a stream, lake, or other water source.
- Keep fire-control equipment out of streams.

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ADDITIONAL ACTIVITIES

- Discuss the reasons for implementing forestry best management practices.
- Invite a forester to discuss with students how best management practices can be carried out on the average farm.
- Arrange for students to visit a logging site and have students list the best management practices they observe in operation.
- Have individual students or pairs of students choose one best management practice and report on it to the class, explaining why this practice should be carried out, how it is done, and the results to be expected.

SUGGESTIONS FOR STUDENT EVALUATION

- The student should select applicable best management practices for a particular timber tract.
- The student should accurately outline those best management practices selected, according to guidelines provided.

SUGGESTED RESOURCES

Gagnon, Jennifer L. *A Guide for Virginia Forest Landowners*. Blacksburg: College of Agriculture and Life Sciences, Virginia Tech, 2011. http://pubs.ext.vt.edu/420/420-139/420-139_pdf.pdf

Virginia's Forestry Best Management Practices for Water Quality: Fifth Edition. Richmond: Virginia Department of Forestry, March 2011. http://www.dof.virginia.gov/water/print/BMP/Manual/2011_Manual_BMP.pdf

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Harvesting Timber Products

ACTIVITIES

► Preparation

Lesson approach

- A commercial forest is managed to produce a timber crop. When the crop is mature, it should be harvested and a new crop allowed to grow. Logging the timber crop is as much a part of good forest management as planting, fire protection, or timber stand improvement. Logging is as important to the commercial forest as harvesting is to the farm.
- Even in forests managed primarily for recreation, harvesting is needed. Intermediate cuttings keep the stand in top shape, open the stand to light, and establish undergrowth needed for wildlife production. Harvesting removes the trees at maturity, before they start the decline, which makes them more susceptible to disease and insects.
- Logging in a commercial forest, to be economical, must obtain the greatest return at the least cost. Many times this means the stand, or some portion of it, must be clear-cut. The scar left by a clear-cut operation is a temporary situation and, in a commercial operation, will soon be covered by a new forest.
- Improper harvesting methods can turn a well-managed, high-quality stand into low-grade timber.
- Through proper harvesting and regeneration, the forest resource is perpetuated.

General situation

- The plans for the harvest should be a part of the total management plan for the timber stand.
- Harvesting is probably the most hazardous job in the total forest production cycle.

Local situation

- Identify local harvesting operations and the type of cutting practice, and determine the silvicultural benefits, if it is an intermediate cutting.
- Identify the end-use markets of the timber being cut, its approximate value per MBF delivered to the processing plant, and the component costs of the harvesting operation.
- Determine who the local logging contractors are and the size and types of equipment and crews that they use in their operation.

► Application

- Arrange for students to visit forest areas to observe various stages of harvesting and the use of the equipment.
- Arrange opportunities for students to observe both portable and large mechanized equipment for harvesting operations in action.
- Arrange for students to visit a stand of timber and recommend and justify the method of harvesting.
- List procedures or steps necessary to develop a harvesting plan.

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► *Presentation: Harvesting Plans*

Selecting trees to be cut

Review the material presented in Lesson 6: Managing the Forest, paying special attention to the sections on intermediate cuttings and harvest cutting. It is important to note closely the selection of the trees to be cut or left in each cutting class. Identify and suggest examples of each type of cutting in the local area.

Planning the operation

Planning a logging operation can be the most important part of the total harvesting procedure. Initial planning can reduce the total logging cost and increase the efficiency of the operation. A balance between the various operations in harvesting must be maintained and accurate information on production must be available to achieve this. The table below depicts a typical operation and shows how the various components have been balanced.

Operation control

It is important that a balance be maintained in all areas of operation. For example, adding more workers in the felling and bucking operation will not increase production unless similar increases are made in other operations, such as bunching or skidding.

Logging system design table

Operation	Equipment	Production per unit (MBF/day)	Number of units for a balanced system	Total production (MBF/day)
Felling & bucking	Power saw, 6 horsepower class	6.7	3	20.1
Bunching & decking	58 drawbar, rubber-tired skidder	22.0	1	22.0
Skidding	Same equipment used for bunching and decking (capacity approximately 0.60 MBF)	20.5	1	20.5
Loading	Hydraulic, tractor mounted (approximately 0.20 MBF capacity)	26.0	1	26.0
Hauling (50 mi.)	41,000 pound gross vehicle weight, 190 horsepower truck with trailer (approximately 4.0 MBF capacity)	8.1	3	24.3

Logging systems

Harvesting is composed of several integrated operations, each one having numerous possible approaches that can be used. The proper organization of the individual operations into the total harvesting operation represents the logging system. Basically, two logging operations can be considered: pulpwood harvesting and sawlog harvesting. The two operations might be conducted independently or simultaneously. Additionally, both types of operations can be subdivided into two types of operations:

- **Shortwood system:** The log is bucked into pulpwood or sawlog length at the stump and is moved from stump to mill in short lengths.
- **Longwood system:** The log is hauled from the woods in tree length and is either bucked at the landing and hauled to the mill in short lengths, or it is loaded and hauled in long lengths and bucked at the mill.

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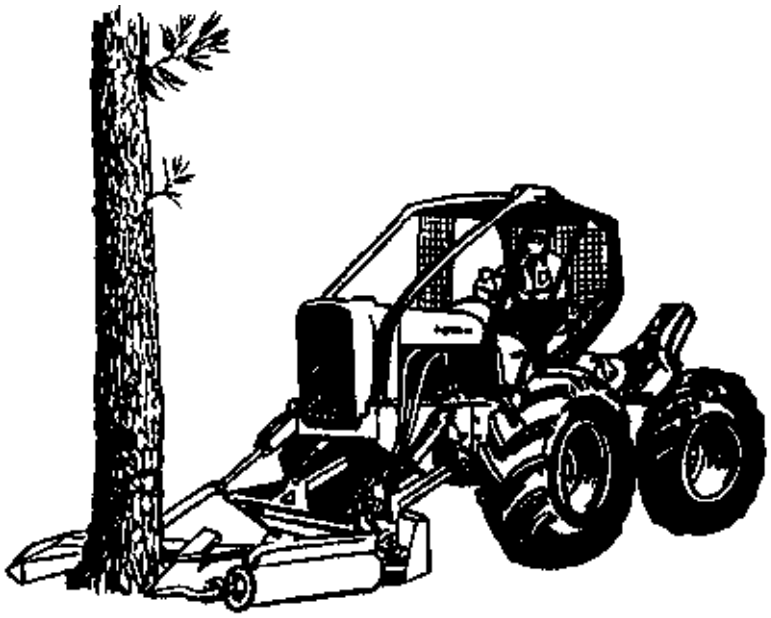
Felling trees

Felling is the initial operation in the manufacturing of wood products. Today, most timber is harvested by mechanized equipment. In situations such as steep terrain, harvest of certain high-value products, or in extremely small operations, hand felling with chain saws is sometimes performed.



Hydraulic Tree Shear

Mechanized felling

Harvesting machine: Several manufacturers are currently marketing tree-harvesting machines. Two general concepts of harvesting machines are used.

- **Feller buncher:** The feller buncher has a felling head that clamps the tree at the base and at several points up the stem. A sawhead is incorporated on the felling head, and the tree can be lifted and placed in an overhead rack after the cut is made. The machine moves from tree to tree, adding each to its load until a full load is gathered. The load can then be moved to a landing or may be dropped for pickup by a skidder.
- **Cut-to-length (CTL) tree harvesters:** The CTL tree harvester incorporates additional equipment to limb, fell, buck, and stack the cut-to-length wood. The harvester machine will normally cut and stack a load or pallet of wood and drop it for movement to the landing by other machinery.
- **Limitations:** Normally, the more complex the harvesting machine, the more dependent it is on terrain and conditions. A skidder-mounted shear can log most stands on which skidders normally operate. On the other hand, a tree harvester is generally limited to flat or slightly sloped terrain, attaining its most efficient production in a plantation type of stand.

Hand felling

Felling crew: A feller equipped with a chain saw is responsible for felling and limbing the tree. In a shortwood system, the feller may also be responsible for bucking the tree to log or pulpwood length.

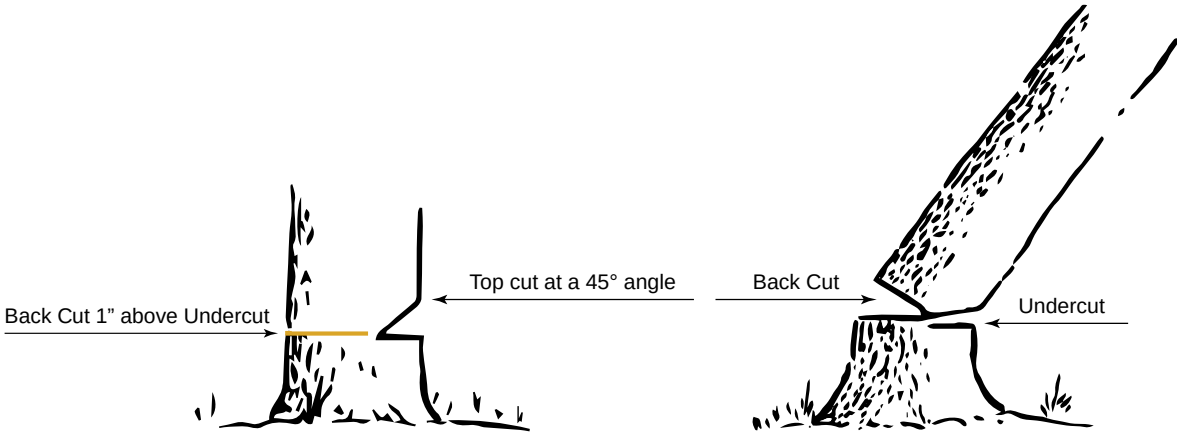
Felling operation layout: The general layout of the felling operation is very important and is the responsibility of the logging supervisor. Proper layout can save time and work and is vitally important for the safety of the crew. Layout should be such that each crew member of the felling team works at a safe distance from all others. Trees should be felled in a manner that permits them to be easily reached by the skidders and allows the fellers to progress through the stand.

Direction of fall: Before starting to saw, the feller should examine the tree to determine direction and location of the drop. A tree with well-balanced limbs around the bole that leans no more than 5 degrees can usually be dropped in any direction. This is done by properly locating the undercut, wedging, and controlling the back cut. Normally, trees that lean more than 5 degrees or have unbal-

anced branching can be directed only 45 degrees to either side of the direction of the lean or center of weight.

A tree should not be felled straight up or straight down a steep slope. A tree felled straight up a slope may kick back over the stump and hit the feller, and trees felled straight down are subject to shattering in the fall. Trees should not be dropped across a rock, stump, or another log because the trunk may break.

Work space clearance: Brush and low-hanging branches should be cleared from the area around the base of the tree and a safe line of retreat should be made available.



Tree cutting

- **Top cut:** The top cut is made on the side of the tree, in the same direction that the tree is to fall. The top cut should be made in a downward direction at a 45-degree angle. The top cut should extend to a depth of about one-quarter to one-third the diameter of the tree.
- **Undercut:** The undercut starts horizontally from the bottom of the top cut. Stop when the cut reaches the end point of the top cut.
- **Back cut:** The back cut should be started one inch above the base of the undercut. Stop at a point that leaves a hinge width of about one-tenth the diameter of the tree.
- **Rotten trees:** Special care should be taken in felling trees with butt-rot. If possible, the cut should be made high enough to avoid the rot. If this is not possible, the back cut should be made by carefully sawing several cuts around the trunk.
- **Lodged trees:** A felled tree that lodges in a standing tree is extremely dangerous, and care should be taken to prevent this from occurring. The safest and most practical method of dislodging a tree is by pulling it down with a machine.

Limbing and bucking

The felling crew usually does limbing at the felling site. The felling crew may do bucking, or the logs may be moved full length to be bucked at the landing or the mill.

Bucking at the mill

With the development of forest product complexes, the trend is toward tree-length logging with the bucking being done at the plant site. Bucking can then be done by large power-driven crosscut saws, and a trained worker can make the bucking decision. The cuts can be made to allow for maximum utilization of the log in one of several plants. Peeler logs can be cut and sent to the plywood mill, sawlogs to the lumber mill, and tops and cull sections can be chipped for pulp.

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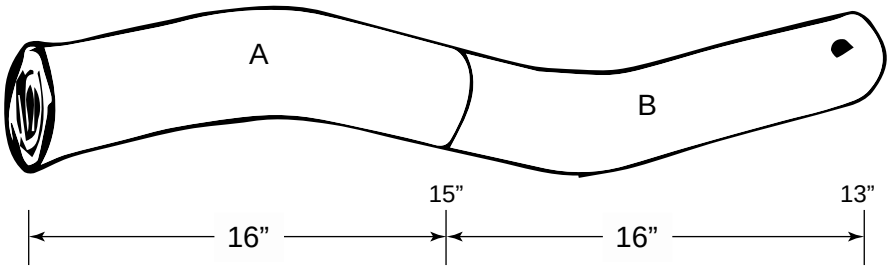
Bucking at the landing

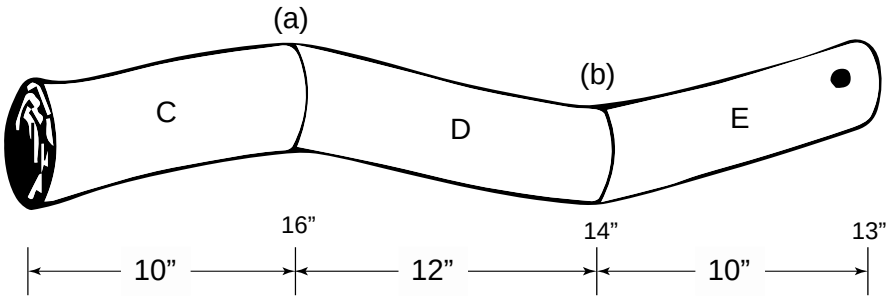
In many instances it is more economical to move tree-length logs to the landing. The bucking can then be done by special machines or trained bucking crews. In tree-length logging, tops can be brought in with the sawlog, then segregated for pulp at the landing.

Bucking alternatives—crooked logs



Not Recommended

Log	Log Grade	Diam. (inches)	Length (ft.)	Gross Scale (Ontario Log Rule)	Net Scale (O.L.R.)	Log Value	Lbr. Value (per log)	Lbr. Value (per MBF net scale)	Lbr. Value per Gross Cu. Ft. of Log Volume
A	F-2	15	16	141	103	9.69	13.57	131.75	0.57
B	F-2	13	16	103	71	4.61	8.80	123.94	0.51
Total (and average) for tree					174	11.30	22.37	(128.56)	(0.54)



Recommended

Log	Log Grade	Dia. (in.)	Length (ft.)	Gross Scale (O.L.R.)	Net Scale (O.L.R.)	Log Value	Lbr.Value (per log)	Lbr. Value (per MBF net scale)	Lbr. Value per Gross Cu. Ft. of Log Volume
C	F-1	16	10	101	101	7.57	17.69	175.15	1.12
D	F-2	14	12	91	91	5.91	11.71	128.68	0.79
E	F-2	13	10	64	64	4.16	7.94	124.06	0.80
Total (and average) for tree					256	17.64	37.34	(145.86)	(0.92)

Handling and skidding logs and bolts

Pulpwood-shortwood system

- **Truck loading at the stump:** This is the simplest method of handling pulpwood, and for a one- or two-person pulpwood harvesting crew, it may well be the cheapest way of producing pulpwood.
- **Prehauling:** In a shortwood system using a larger crew, the pulpwood can be stacked on pal-

lets by the felling-bucking crew and then picked up by a prehauler and moved to the landing. The prehauler may be a specially designed tractor built to carry one or more pallets, or it may be a tractor pulling the pallets on skids.

- **Tree-length skidding:** The logs are skidded to the landing by crawler tractors or rubber-tire skidders. If the logs are widely scattered, a bunching tractor may be used to move the logs together to allow the skidder to pick up a full load. If the logs are close together at the logging site, the bunching can be done with a power winch on the skidder. Bunching and short skids can be made by dragging the logs behind a tractor. On long skids, the leading end of the logs should be raised off the ground. This is usually done with a logging arch that is high enough to lift the front end of the load from the ground. On most machines designed for skidding, the arch is an integral part of the machinery. Securing the log is done by either using a wire rope looped over the log end, called a "choker," or by a hydraulic grapple mounted on the skidder, called "chokerless skidding."

Sawlogs

Sawlogs are usually skidded to a landing either in log lengths or tree lengths. The skidding practice is similar to that used in tree-length pulpwood skidding.

Loading the timber

The loading operation in most logging operations is mechanized. Occasionally on small pulpwood operations, loading may still be done by hand.

Truck-mounted loaders: In a one- or two-truck operation from a landing and in most pulpwood operations loading at the stump, truck-mounted loaders are used. Since the truck driver serves as the loader operator, a worker and separate machine do not sit idle at the landing waiting for the truck to make a round trip to the mill.

Loaders: Operations involving several trucks are better suited to the use of one of the many available types of loaders. These fall into two general groups—front-end loaders mounted on tractors, and boom or crane loaders, either on truck bodies or as self-propelled units.

Hauling the timber

Several variables affect the cost of log hauling. To determine the proper size and number of trucks, the following should be considered.

Material: The truck should be designed to carry the material being hauled. Pulpwood bolts, logs, tree-length pulpwood, and tree-length sawtimber all may require different types of truck.

Delay and standby: Some delay and standby time while waiting for loading and unloading is unavoidable. Care in planning and scheduling of trucks to the landing and delivery point can minimize these delays. "Hot loading" (loading directly from the skidder to the truck) can cause delays. This can be avoided by maintaining enough logs at the landing to load all trucks as they arrive.

Length of haul: On short hauls, smaller trucks are more economical; on long hauls, larger trucks are better. This is because the loading and unloading time on short hauls represents a higher percentage of the total hauling time.

Road standards: A haul involving high mileage in woods and on secondary roads will be more expensive and require more trucks than a haul mostly made on paved roads.

Chipping the total tree

Total tree chipping requires a special piece of equipment designed to chip trees up to 22 inches in diameter. The trees are severed at the stump and then skidded to the chipper.

The chipper has grapples that pull the butt end of the tree into the mouth of the chipper. Rollers then feed the total tree into the body of the machine, where it is converted to chips. The chips are blown

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from the machine into a tractor-trailer van and transported directly to the pulp mill.

A total tree harvesting and chipping operation uses most of the wood fiber on the site. This makes it more convenient and less costly to prepare the area for tree planting.

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ADDITIONAL ACTIVITIES

- Have students define terms related to logging and hauling timber.
- Arrange for students to visit a logging site and observe the equipment used in felling, limbing, and bucking operations, and observe a chipping operation, discussing the advantages of total tree chipping.
- Have students discuss and demonstrate how to determine the direction of fall for a felled tree. Have students outline the felling procedure to make trees fall in various directions.
- Have students discuss the safety hazards connected with the felling of trees and how to avoid kickback and lodging; emphasize procedures for dealing with leaning, rotten, and lodged trees.
- Have students compare and contrast the shortwood and longwood systems of harvesting.
- Have students review information on intermediate cutting in Lesson 6, and discuss tree selection and reasons for harvesting trees in noncommercial forests.
- Have students discuss the cost factors associated with hauling logs.
- Have students observe felling, limbing, and bucking operations; demonstrate or discuss how to determine bucking cuts in crooked logs.

SUGGESTIONS FOR STUDENT EVALUATION

- A plan of logging activities should include the following and be rated acceptable according to instructor-prepared checklist:
    - ◊ Rough sketch of the tract with roads and clearings marked
    - ◊ Procedure for tree selection and the product(s) to be sold
    - ◊ Market location
    - ◊ Types and numbers of workers and equipment needed
    - ◊ Plans for felling, limbing, and bucking
    - ◊ Schedule and plans for loading, hauling, and unloading
    - ◊ Estimated time schedule for logging activities and clean-up
    - ◊ Safety regulations and precautions to be observed.

SUGGESTED RESOURCES

Health and Safety Code Handbook. Washington: USDA, Forest Service, 1999. http://www.fs.fed.us/im/directives/fsh/6709.11/FSH6709.pdf

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TEACHER NOTES

Processing Timber Products

Lesson

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SOL CORRELATIONS

Earth Science
ES.7
English
9.1
9.6
10.1
10.6
11.6
12.1
12.6
Mathematics
A.4
Civics and Economics
CE.9

EQUIPMENT, SUPPLIES, AND MATERIALS

- Instructor-provided report guidelines and rubric
- Tape measure or grader's rule
- Lumber for grading
- Instructor-prepared vocabulary sheets
- Instructor-prepared test on lumber grading

TEACHER: _____

SCHOOL: _____

GRADE LEVEL: 9–12

TASKS/COMPETENCIES

- Demonstrate the ability to operate processing equipment (optional).
- Describe sawmill safety, operating equipment, and first aid procedures.
- Describe general sawmill operations activities.
- Demonstrate the ability to operate a carriage (optional).
- Define terms used in lumber grading.
- Identify boards as hardwood or softwood.
- List the reasons for grading lumber.
- Identify the grades used for hardwood and softwood lumber.
- List the steps to follow when evaluating lumber.
- Grade a stack of lumber.

OBJECTIVES AND GOALS

- The student should be able to identify the types of sawmills and headrigs, and state the function of each.
- The student should be able to outline the operation of the carriage, the edger, and the trimmer.
- The student should be able to explain the basic layout of the typical sawmill.
- The student should be able to compare the processes of sawing for grade and sawing for maximum production.
- The student should be able to identify and describe the factors that influence quality control in sawmills.
- The student should be able to identify the byproducts of sawmill operation and describe how they are used.
- The student should be able to describe the major wood-using industries and their place in the state's economy.

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ACTIVITIES

► Preparation

Lesson approach

- Wood grows in a round form and is primarily used in a sheet or board form. Processing of timber products involves the conversion of the round log into the rectangular sheet, board, or chips.
- The properties of the final product depend on many variables, such as the species of wood, its rate of growth, the conversion method used in producing the product, the place in the tree from which it was obtained, and the treatments that it has received.
- Virtually any piece of wood can be converted into a marketable wood product if the value of the product will cover the total cost of the conversion.

General situation

- The wood-processing industry is one of Virginia's most important industries.
- Markets for timber products in Virginia can be divided into the following four general classes, ranked according to total value of timber consumed:
    - ◊ lumber, timbers, and other sawed wood products
    - ◊ pulp, particle, and fiber products
    - ◊ plywood and veneer
    - ◊ posts, poles, and pilings
- From the processing standpoint, lumber and sawed wood products are an important industry in most areas of the state. The other three classes are important to the state as a whole and are of prime importance in those areas in which plants are located.
- The sawmilling industry is changing from an industry represented by small, portable mills to one of fewer and larger stationary mills.

Local situation

- Determine the wood-processing plants in the local area. Identify their products, raw material requirement, and available workforce.
- The content of this section should be adjusted to the local situation. If the local area has a pulp and paper mill, veneer and plywood plant, wood treating plant, or furniture plant, these topics should be included with assistance from local industry personnel.

► Application

- Arrange for students to visit wood-processing plants and observe the processing or manufacturing of various products.
- If possible, arrange for students to participate in supervised work projects at local wood processing plants or mills.

► *Presentation: Lumber Processing*

Lumber and sawed wood products

There are approximately 500 sawmills presently operating in Virginia. These mills consume 46 percent of the timber volume cut and account for 60 percent of the value of timber cut.

Types of sawmills

Sawmills are generally classified by three factors.

Species cut

- Hardwoods
- Softwoods
- Mixed

Mobility of the sawmill

- A portable mill is one that is moved to a location near the timber supply.
- A stationary mill is one located at a permanent site to which the logs are transported from the logging site.

Type of headrig

Circular headrig: The primary breakdown saw is a circular saw, which is a disk with teeth on the outside perimeter. All portable mills and many stationary mills in Virginia use the circular headrig.

Band headrig: The primary breakdown saw is a continuous band with teeth on one side. Because of its large size and the need for more permanent foundations, the band saw is used only in stationary mills.

Chipping headrigs: Chipping headrigs are large, partially automated units that chip the outer portion of the log and saw the remainder into lumber and timber products. Chipping headrigs are continuous operations, with the log feeding into one end and the products coming out the other end. All mills that use chipping headrigs are stationary.

Other headrigs: Although not used often in Virginia, several other types of headrigs are available for initial log breakdown, including gang mills, scragg mills, and multiple saw headrigs (both band and circular).

Basic sawmill equipment

Three types of machines are needed in any sawmill. Smaller mills may operate with only these three units, while larger mills will operate the three units along with additional equipment.

1. Headrig

The headrig converts the round log into rectangular units. The headrig may handle the complete breakdown or it may be used for initial breakdown into units that can be further sawed on accessory equipment. The headrig is limited to making cuts in one plane of the log. The plane of cut can be changed by rotating the log before making a cut. Once the initial plane has been established by the first cut, all other cuts are either parallel or perpendicular to the initial plane.

The headrig is a unit composed of machinery serving four basic parts:

- **Saw**
- **Log-holding mechanism:** The log must be restrained from turning or twisting as the cut is made. To ensure that boards will have parallel faces and squared edges, each cut must be accurately maintained as parallel or perpendicular to all other cuts.
- **Log-moving mechanism:** To be cut, the log must be moved into and through the saw.
- **Lateral indexing mechanism:** In headrigs using a single saw (circular or band), one cut is made to obtain each board. The log is then moved laterally to a distance equivalent to the thickness of the desired board, and a second cut is made.

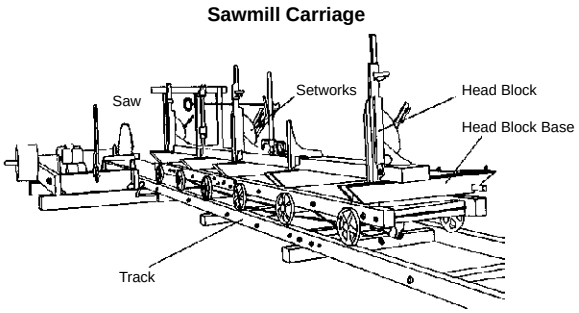
In most mills, the log carriage performs the latter three functions.

- **Carriage and log movement:** The carriage is mounted on tracks that run parallel to the saw. By moving the carriage along the tracks, the log is moved through the saw.
- **Superstructure of the carriage:** The carriage has a superstructure composed of a series of

head blocks (knees) and head block bases (bolsters). The bolsters are mounted horizontally on the carriage, perpendicular to the saw. These form the base on which the log rests. The head blocks are at right angles to the base, and they provide additional support for the log and prevent it from moving away from the saw. To prevent the log from moving toward the saw and to prevent turning, pointed metal hooks (dogs) are mounted on the head block. These dogs extend out from the head block and are driven into the top of the log.

Setworks

To index the log laterally, the head blocks are moved laterally along the head block bases. The mechanism for this is called the setworks. The setworks may be automated, and if this is the case, the headsawyer controls it. On older or non-automated carriages, the setworks is operated manually through the use of ratchets and gears.



The headrig is operated by one, two, three, or four individuals. Automation has made it possible for a single person (the headsawyer) to control the total headrig. Without automation, a "setter" rides the carriage to operate the setworks, along with one or two "doggers." (In small mills, the setting can also be done manually by the sawyer.)

2. Edger

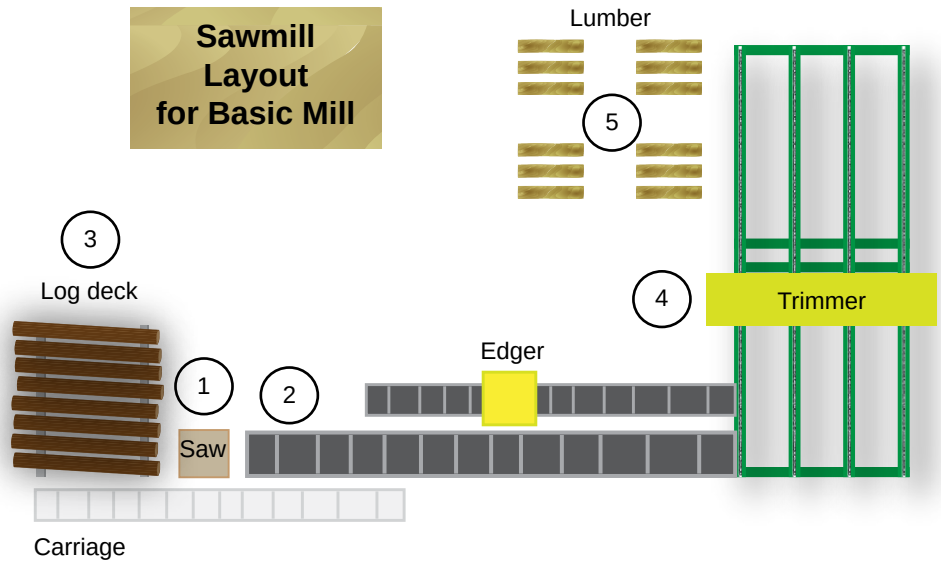
The boards cut from the periphery of the log contain edges that are neither square nor parallel. To produce lumber of standard width and squared edges, these boards are again sawed on the edger. The edger has two or more saws arranged on a common shaft, with one or more being movable along the shaft. The position of the saws determines the width of the boards, and the two saws provide parallel and square edges. The edger can also be used to cut narrower high-grade boards from wide, low-grade boards.

3. Trimmer

As they come from the headsaw and edger, the ends of the boards and timbers may not be parallel or square, or the boards may not be standard length. They must then be trimmed. The trimmer may be a hand-operated swing saw or it may be a battery of saws mounted to cut the boards to length. The trimmer can also be used to upgrade lumber by segmenting the board into shorter lengths of higher grades.

Basic mill layout

The figure below shows a typical mill layout of a basic sawmill system. The numbers indicate the worker requirements: (1) sawyer, (2) edger, (3) decker, (4) trimmer, and (5) piler.



Lesson

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Additional equipment

The headsaw, edger, and trimmer are basic items needed in all sawmills. In many cases, small mills operate with only these three items. As the complexity of the mill increases, additional equipment is added. The individual types and designs of additional equipment are many and varied, but the general functions can be isolated and discussed.

Debarker: In the past, logs have normally been sawed with the bark on the log. However, a general trend toward debarking before sawing has occurred. Three factors have contributed to this increase in debarking.

The primary factor is that a market has developed for chipped waste wood for pulp. If edgings (the portion of the board removed from the lumber by the edger) are bark-free, they can be chipped and sold to pulp mills.

The life of the sawblade is an important consideration. It has been found that the saws can be used longer between sharpenings and replacement if the bark, with its dirt, gravel, and other foreign objects, is removed.

Debarking allows the sawyer to see and identify defects so the log can more easily be positioned for maximum recovery.

Log loader and turner: A log can be loaded on the carriage and turned by hand, but efficiency is increased by the addition of mechanical loading and turning devices.

Resaws: In all mills, the headsaw generally controls the rate of production. To increase the mill production, a second headsaw may be installed; however, much greater efficiency usually can be obtained by the addition of resaws. The headsaw can break the log into multiples of boards and timbers, and a secondary breakdown or resaw can cut the individual components. To saw the log shown below on a headsaw would involve fourteen cuts and three turns (Figure A). Using resaws, the same log can be cut with two cuts and two turns on the headsaw (Figure B).

Cutting on Head Saw vs. Cutting into Cants and Resawing

Figure A

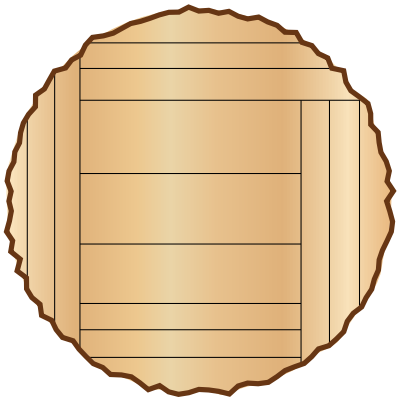
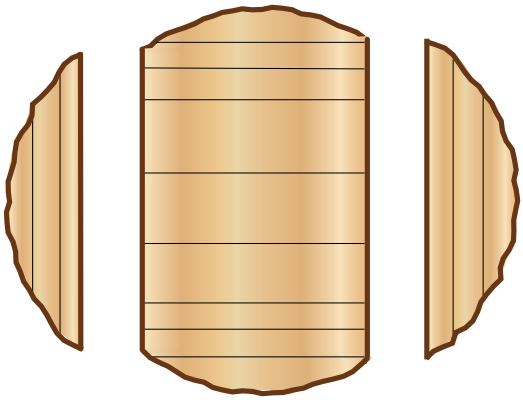


Figure B



Separators and stackers: After the lumber has been cut, edged, and trimmed, it must be stacked for shipping or drying. Green lumber is usually sorted for size and species on the green chain, which is a conveyor belt or table from which the lumber can be pulled and stacked. Automated equipment is also available for selection according to size and for stacking lumber.

Dryers: Lumber should be dried according to the moisture content at which it will be used. Lumber from the log will contain anywhere from 35 to 50 percent moisture by weight and must be dried to 7 to 10 percent for interior use, or 12 to 18 percent for exterior use.

- **Air drying:** Lumber stacked and exposed to the air will dry to about 15 percent moisture content over a period of several months.
- **Kiln drying:** To dry lumber to a moisture content of 7 to 10 percent, or to accelerate the drying, large temperature and humidity control chambers called dry kilns are used. Kiln drying of lumber is a specialized procedure; incorrect methods can severely degrade the lumber.

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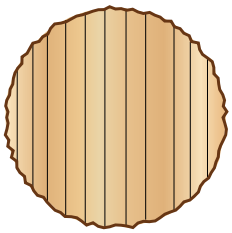
Sawing procedure

Two approaches may be used in sawing logs: sawing for maximum grade and sawing for maximum production. It has been commonly accepted that when sawing logs that contain high-grade lumber, the maximum value of lumber can be obtained by sawing to maximize the grade recovery. Low-grade logs that contain little or no high-grade lumber should be sawed to maximize production. Recent studies indicate, however, that sawing even high-grade logs for maximum production may provide the highest value return per log.

- **Sawing for maximum production:** Grade sawing decreases production because the log must be turned to each face to saw the high-grade boards, whereas "through and through" sawing (gang sawing) involves a minimal turning of the log. In gang sawing, the initial face is selected to maximize grade recovery. Boards are taken in the order of those nearest the log center first, then the log is turned 180 degrees and boards are taken from the opposite direction. Figure C illustrates this sawing method.
- **Sawing for grade:** The high-grade lumber occurs in the outer shell of the log. Grade sawing involves sawing around the log, taking the high-grade lumber from the outer shell and leaving the center for use as timbers, dimension lumber, or low-grade boards.

Figure C



"Through-and-Through," or Gang, Sawing

Log faces: When sawing for grade, the sawyer must make initial sawing decisions based on the appearance of the log. By viewing the exterior and ends of the log, an idea of the defects that will appear in the boards can be obtained.

- Knots on the exterior will usually extend to the center of the log.
- Bumps on the exterior are indicative of a limb that has been removed or dropped off and has grown over. The sawyer knows that under the bump, a knot will be found. The size of the bump and the slopes of its sides will indicate the size of the knot and how far under the surface it is likely to appear.
- If a face is completely clear of knots or bumps, the sawyer will know that lumber sawed from this face will be of a high grade. If the log has all four faces clear, the log will produce high-grade lumber from all four cutting faces. Based on the number of clear faces and their relative position on the log, the sawyer decides how the log will be cut.

Taper and Taper-Sawing

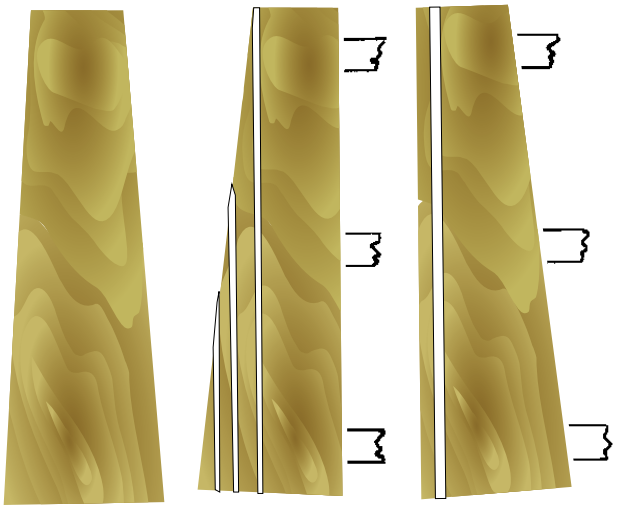


Figure D Figure E Figure F

Taper sawing: A special adaptation of grade sawing is the technique called "taper sawing." The bole of a tree does not grow as a true cylinder, but rather as a truncated cone with the diameter at the butt larger than at the top. This decrease in diameter up the bole is called "taper." The grain of the wood follows the exterior of the log and is not parallel to the center, and the grain on opposite sides of the

log is not parallel. If the log is placed on the carriage with no consideration for taper, the first face cut will be cut in a plane parallel face that is against the head blocks. The resulting boards will not be parallel to the grain of the wood and the resulting lumber will contain gross grain (Figure D).

When the log is turned, the back side will automatically be sawed parallel to the face. Thus, if one face is a low-grade face and the opposite face is a high-grade, the high-grade face can be taper-sawed by placing it against the head blocks and initially cutting the opposite poor face (Figure E).

If both faces are high-grade, the head blocks of the small end of the log can be set forward so the outside face is parallel to the saw (Figure F). When the log is turned, the blocks must be adjusted again so that the original back face can be sawed parallel to the face of the log. Once the high-grade lumber has been taper-sawed and only low-grade material remains, the center cant is squared up by sawing off the wedges that are a result of the taper-sawing.

Machinery balance: In a simple sawmill operation with a headsaw, edger, and trimmer, maintaining machinery balance in the production process is manageable. The headsaw should set the production of the mill. If either the edger or trimmer control the production rate, the mill is out of balance and that unit should be replaced with one capable of keeping up with the headsaw.

In more complex mills, keeping machinery balanced can be a greater problem. The operator will have a choice of machines capable of performing a given cut. The flow of material must be adjusted to provide maximum utility of all machines, as well as maximum production from the mill.

In most mills, balancing is done by trial and error. The headsawyer determines how much breakdown should be done on the headsaw and decides where the remaining cutting should be done. Usually material is sent to a secondary breakdown machine to maintain all machines operating at full capacity, rather than to ensure maximum efficiency; unfortunately, full loading of all machines may not produce maximum mill efficiency.

A good mill manager or headsawyer may be able to improve efficiency through experience, but to assure maximum efficiency, the total mill balance for the various types of raw material and products should be determined. Advanced techniques are available to make these studies.

Quality control: The quality of the manufacture of lumber in the mill is as important as the quantity. In the sawing operation, two factors are important to the quality of the lumber produced.

Thickness

- Lumber sawed too thick will have a decrease in the recovery of material from the log. The excess thickness must be planed off to make the lumber usable.
- Sawing lumber too thin will reduce its value, and before it can be used, it must be planed to the next thinner board size.
- The lumber thickness control depends on the accuracy and dependability of the setworks. A well-adjusted set work should be able to cut to ±1/16 inch in lumber thickness.

Uniformity: The thickness of a board may vary along its length. The size of the thinnest point will determine the usable thickness, because to use the board, it must be planed to a uniform thickness. Thick and thin lumber can result from several causes:

- **Poor alignment of tracks:** If the carriage tracks are not parallel to the saw's cutting plane, the lumber will be thicker at one end than the other.
- **Log not held properly:** If the log slips or moves on the carriage while the cut is being made, or between cuts, the board will not be uniform in thickness.
- **Misaligned head blocks:** If the head blocks are not aligned accurately, uniform lumber cannot be cut.
- **Head block base and knees not square with saw:** If the head block is not perpendicular to the saw or the knees are not perpendicular to the base, the boards will be thicker on one side.

A simple quality-control program should be conducted in every mill. A random check on the thick-

ness of lumber being produced by the mill should be made several times a day to provide the manager with necessary information to ensure proper manufacture of the lumber.

Byproducts

Although the production of lumber and sawed wood products is the primary objective of the sawmill, the economic state of the operation may be determined by the extent of byproduct use. In addition to lumber, the sawmill produces three other types of material—bark, wood waste, and sawdust. Much has been done to develop uses for these materials.

- **Bark:** Only recently has a market for bark developed and grown. The greatest portion of bark is used for horticultural and landscaping purposes such as mulch, soil conditioner, and ground cover.
- **Wood waste:** In the sawing of the log, a portion of the solid wood is unusable for lumber. Most of this wood is the portion that must be cut from the round shape to produce the rectangles, slabs, and edgings. Any waste whole wood can be chipped and sold as pulp chips if a market is available. Some pulp mills will take only softwood chips; some will take mixed chips, but usually they must be separated into hardwood and softwood. Slabwood and edgings are also sold for residential firewood use.
- **Sawdust:** Since 1973, sawdust has been used increasingly as a fuel in industrial furnaces, mainly in the large pulp and paper industry. Some is used in papermaking, particle board, mulch, and for animal litter.

Pulp, particle and fiber products

Pulp and paper mills and oriented strand board plants consume much of the round wood produced each year in Virginia. In addition, pulp and paper mills, particle board plants, and fiber board plants consume a large quantity of chips and shavings from other wood products plants.

Plywood and veneer

The plywood and veneer industries are important consumers of timber in Virginia. Plywood is used in home construction, furniture making, and for many other purposes. Veneer is made from high-quality trees and used to “face” other less-desirable woods. Veneer timber supports a premium price.

Posts, poles, and pilings

Some of the state’s timber harvest is consumed as posts, poles, and pilings. All of the poles and pilings and some of the posts are processed at the state’s wood preservative treatment plants. Additionally, they treat lumber, timber, and plywood.

Remanufacturing plants

Much of the sawed wood products produced by the sawmills are used as raw material for other industries in the state. Remanufacturing plants include furniture plants, container plants, flooring plants, pallet plants, planing mills, millworks, and prefabricated home manufacturers.

Chip mills

A chip mill converts pulpwood into chips for use in papermaking. Pulpwood is wood fiber that sawmills will not purchase: tops of trees, deformed trees, thinnings, and undesirable tree species. Different kinds of trees make different kinds of paper. Hardwood trees (such as oak and birch) make great bathroom and facial tissue. Softwood trees (such as pine and fir) are used where strength is required. Grocery bags and corrugated boxes are made predominately of softwood fiber. Printing and writing papers require a mix of hardwood and softwood fiber.

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ADDITIONAL ACTIVITIES

- Have students discuss, outline, or diagram the basic sawmill operation, including the function of each piece of machinery and each worker.
- Arrange for students to visit a sawmill and observe the equipment in operation.
- Invite a local sawyer to discuss or demonstrate how logs are cut for grade and for maximum production; how machine balance is maintained in the sawmill; the quality-control measures implemented at the mill; and how byproducts of the sawmill operation are used.
- Arrange for students to visit local wood-using industries and identify the industry's products, the raw materials required, and the workforce drawn from the local area.

SUGGESTIONS FOR STUDENT EVALUATION

- Students should take a test on lumber processing and sawmill operation.
- Students may write a two- to three-page report on the importance of lumber processing in forest management and in the local economy (evaluated according to an instructor-prepared rubric).

SUGGESTED RESOURCES

Lunstrom, Stanford J. *Circular Sawmills and Their Efficient Operation*. Washington: U.S. Department of Agriculture, Forest Service, reprinted 1993. http://www.fpl.fs.fed.us/documnts/misc/circ-saw.pdf

Lesson

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Grading Lumber

ACTIVITIES

► Preparation

Lesson approach

- It is not the purpose of this unit to teach students the actual skills needed to grade lumber; however, it is important that students understand the process so they may judge the quality of lumber and how it affects the economy of forest management.
- Plan a tour of local sawmills, lumber concentration yards, or retail lumber yards so that students can observe and compare various grades of lumber, particularly the different hardwood and softwood grades.
- Determine the number of qualified lumber graders in the local community and make students aware of the career opportunities in this field.

General situation

- There are few qualified lumber graders in Virginia; there is a demand for this skill.
- Lumber industries sponsor courses in lumber grading to help meet this demand.

Local situation

- Before beginning instruction on this unit, determine the number of qualified graders, the number of lumber businesses needing qualified graders, and the assistance available from local businesses to students interested in learning this skill.

► Application

- Have a professional lumber grader pregrade several hardwood and softwood boards. Have students evaluate and grade the boards, giving reasons for the grades they assign.
- Arrange a tour of lumber businesses so students can observe the lumber-grading process.
- Invite a lumber grader or local lumber business owner to discuss job opportunities with students.

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► *Presentation: Lumber Grading*

Reasons for grading

Measuring quality

- Lumber grades are a means of measuring the quality of lumber.
- Lumber grades provide the buyer and seller with a "yardstick" for measuring quality and enable the purchasers to buy the grade or grades that best suit their needs.

Establishing prices

Lumber grades serve as a basis for establishing prices.

Establishing grades

The specifications for most jobs requiring lumber call for particular grades.

Advantages of grading to the industry

Buyer

Grading provides a standard for ordering and guarantees suitable quality.

Producer

Grading provides a standard for selling and widens the market from local to nationwide.

Middle vendor

Grading provides a method for operating without the necessity of seeing or taking possession of the lumber.

Quality improvement

The manufacturing or mismanufacturing of lumber at the mill has a tremendous effect on lumber grades, and a few simple steps taken at the mill can improve lumber grades considerably. In hardwood lumber grading, for example, there are specific allowances for wane, splits, and pith; defects exceeding these specifications will cause the boards to be assigned less than a top grade. Proper edging and trim saw cutting can eliminate most of these defects and thus improve the grade.

Hardwood and softwood lumber grading

Hardwood lumber grades are entirely different from pine lumber grades. Pine is generally used in construction in the full width, thickness, and length that is cut at a sawmill. Because the grades are based primarily on strength, the size and distribution of knots are important. Pine is graded on the best side of the board. Hardwood lumber is generally sold to a manufacturing plant that cuts the boards into much smaller pieces to make products such as furniture, boxes, and flooring. Hardwood lumber is graded primarily on the basis of the proportion of the board that can be cut into clear pieces, and the board is usually graded on its poorest side.

Hardwood definitions

Surface measure (SM): This is the square-foot surface of the board and is also called the board measure. To determine the surface measure of a board for grading purposes, multiply width (in inches) by length (in feet) and divide by 12; round to the nearest whole number. For example, the surface measure of a 5-inch by 14-foot board = 5 x 14/12 = 5-5/6, rounded to 6 feet SM.

Cutting: This is the part of a board that can be obtained by cross-cutting, ripping, or both. The part (or cutting) cannot be less than the minimum dimensions specified for each grade.

Clear face cutting: This is a cutting having one clear face and the reverse side sound, as defined below. The clear face of the cutting is on the poor side of the board except when otherwise specified. Admissible defects are ordinary season checks, unlimited sapwood, mineral streaks and spots, burls, and stain, provided it will dress out. Cuttings must be smaller than certain minimum sizes designated for each grade of lumber. For example, for a grade of FAS (First and Seconds), the minimum size is 4 inches by 5 feet or 3 inches by 7 feet. For No. 2C, cuttings may be as small as 3 inches by 2 feet.

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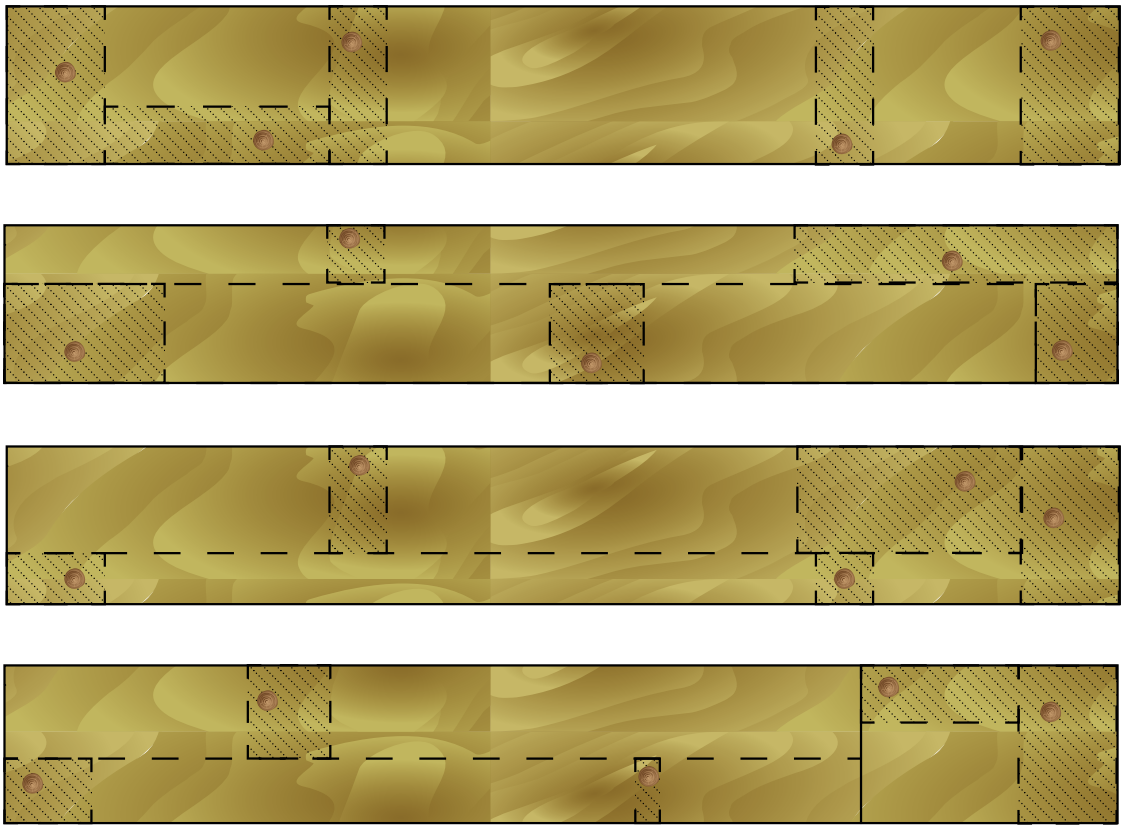
Sound cutting: A cutting free from rot, pith, shake, and wane is considered sound. It will admit sound knots, sound bird pecks, stains, streaks or their equivalent, season checks not materially impairing the strength of the cutting, pin, shot, and spot worm holes. Other holes a half-inch or larger are admitted but shall be limited as follows: two one-quarter inch or one one-half inch in diameter to each 12 units (144 square inches) and only one side of a cutting. Texture is not considered in sound cutting.

Mechanics of grading: With some exceptions, hardwood lumber is graded on the basis of the size and number of cuttings (pieces) that can be obtained from a board when it is cut up and used in the manufacture of a hardwood product such as furniture, flooring, or interior house trim. The best grade has the largest area of usable material; when cut up for remanufacture, nearly all of the best grade can be used in a small number of large-sized cuttings. Lower-grade boards will produce several smaller-sized cuttings.

The following drawings are examples of how hardwood boards might be cut to get clear cuttings. The dark circles represent the knots, and the shaded portion represents the lumber that would be thrown away as waste; the dashed lines represent the saw cuts.



Standard grades: Hardwood lumber is classified as follows:

- First
- Seconds
- Select
- No. 1 Common
- No. 2 Common, Sound Wormy
- No. 3A Common
- No. 3B Common

Grade combinations: Lumber may be sold separately by each grade or in the following combinations of grades:

- FAS—First and Seconds, usually combined as one grade
- Selects—generally speaking, FAS on the good face and No.1 Common or better on the poor face
- No. 1 Common and Better—the full run of the logs with grades below No.1 Common exclud-

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ed
- No. 1 Common and Better (Log Run)—the full run of the logs, excluding all grades below No.1 Common as defined for the various species under "standard inspection"
- No. 3B Common and Better (Mill Run)—the full run of the logs; below grade lumber excluded
- No. 3A Common and 3B Common—may be combined as No. 3 Common

Simplified Hardwood Standard Lumber Grades						
	FAS	**Selects**	**1 Common**	**2 Common**	**3A**	**3B**
Width	6" +	4" +	3" +	3" +	3" +	3" +
Lengths	8-16'	6-16'	4-16'	4-16'	4-16'	4-16'
No. of cuttings allowed	SM 4	SM 4	SM +1 3 (not over 5)	SM 2 (not over 7)	No Limit	No Limit
Minimum size of cuttings	4" x 5' or 3" x 7'	4" x 5' or 3" x 7'	4" x 2' or 3" x 3'	3" x 2'	3" x 2'	1½" x 2'
Amount required CF cuttings	10/12	10/12 FAS good side—1 Com or better on poor side	8/12	6/12	4/12	3/12 (sound cuttings)
PITH	Length in inches no greater than SM	Same as FAS	One-half the length	No limit	No limit	No limit

Grading procedure
- Determine the species.
- Determine the SM, using a lumber scale stick.
- Determine the poor side of the board. (The hardwood grade is determined from the poor side of the board, except when otherwise specified.)
- Assume the grade of the board.
- Determine the number of cuttings permitted in the assumed grade.
- Determine the clear-face cutting units needed.
- Determine the area of permitted clear-face cuttings in units.
- If the board does not yield sufficient clear-face cuttings, units of the right size, and number of cuttings, try the next lower grade.
- Tally the SM by grade and thickness on basis of 1-inch lumber, as follows:
  - ◊ Random-width lumber of standard grades and thicknesses is the tallied surface measure and this tally is the number of feet, SM, of 1-inch lumber.
  - ◊ In lumber thicker than 1 inch, the tally so obtained is multiplied by the thickness as expressed in inches and fractions of an inch. For example, for 5/4 lumber, add ¼; for 6/4 lumber, add ½; for 8/4 lumber, multiply by 2. Lumber less than 1 inch thick shall be measured and tallied as 1-inch lumber.

Softwood definitions

Check: A lengthwise separation of the wood, most of which occurs across the rings of annual growth.
Decay: A disintegration of the wood substance due to the action of wood-destroying fungi. It is also known as "dote" and "rot." Firm red heart is a stage of incipient decay characterized by a reddish color produced in the heartwood, which does not render the wood unfit for the majority of yard purposes.
Holes: May extend partially or entirely through a piece due to any cause. When holes are permitted, the average of maximum and minimum diameters measured at right angles to the direction of the hole shall be used in measuring the size, unless otherwise stated.
Knots: A segment of a branch or limb embedded in the tree that has been cut through in the process of lumber manufacture. Knots are classified according to size, form, quality, and occurrence.
Mismanufacture: All imperfections or blemishes produced in manufacturing.

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Pitch: An accumulation of resin in the wood cells found in a more-or-less irregular patch.
Pith: The small soft core occurring in the structural center of a log. The wood immediately surrounding the pith often contains small checks, shakes, or numerous pin knots, and is discolored; any such combination is known as heart center.
Shake: A lengthwise separation along the grain, most of which occurs between the rings of annual growth.
Split: A lengthwise separation of the wood extending through the piece from one surface to the opposite, or adjoining, surface.
Stain: A discoloration occurring on or in lumber of any color other than the natural color of the piece.
Wane: Bark, or the lack of wood due to any cause, on the surface of lumber.
Warp: Any variation from a true or plane surface. It includes bow, crook, cup, or any combination thereof.

Grading mechanics: Softwood is usually used as a whole piece and graded from the better face according to the defect method. To a great extent, grade is based on strength. The main consumption of softwood lumber is in construction.

Grading classifications of softwood lumber
Yard lumber: Ordinarily used for general construction; carried in stock by the retailer.
Structural lumber, timbers, dimension: Lumber 2 inches or more in thickness, to which definite work stresses are assigned.
Factory, shop: Usually used for remanufacturing purposes.

Lumber grades

Select

- **A Finish:** One face practically clear, in a width 12 inches or less.
- **B Finish:** Will admit small surface checks, slight cup, one short split in end, several small knots, or a small percentage of stain.
- **C Finish:** Will admit the following or equivalent: medium surface checks, slight cup, medium split, an average of six pin holes per surface foot, small knots, light pitch, 25 percent firm red heart, and other minor defects.

Common

Standard widths for all common grades are 2 inches and wider; standard lengths are 4 to 20 feet.

- **No. 1 Common:** Pattern must be suitable for use without waste, and will admit the following or the equivalent: sound, firm knots; medium cup; checks; a limited number of pin holes well scattered; pitch pockets; pith; medium shake; medium splits; firm red heart; light stain.
- **No. 2 Common:** Will admit the following, or equivalent: knots not necessarily sound, deep cut, medium holes, deep torn grain or other imperfections in dressing that will not cause waste, pitch pockets, firm red heart, streaks of advanced decay.
- **No. 3 Common:** Must be suitable for use as a whole for low-cost sheathing and will admit the following, or equivalent: large knots, loose knots, decayed knots, splits, through checks, through shakes, mismanufacture, pitch pockets, pitch, red heart, stain, wane.
- **No. 4 Common:** Will admit all pieces that fall below the grade of No. 3, excluding such pieces that will not hold in place by nailing after wasting one-quarter of the length of the piece by cutting into two or three pieces.

Career opportunities available to lumber graders

Considerations

- There is a demand for qualified lumber graders.
- Lumber grading is a respected job that pays well.
- Jobs are not confined to any one area or region.
- Modern working conditions are provided through the modernization and mechanization of equipment and facilities.

Advancement

The knowledge of grading is the basic requirement for advancement to supervisory, purchasing, sales

management, and ownership positions.

Training requirements

- A high school education is preferred. A grader must be in good physical condition and have an aptitude for figures and an ability to work with people.
- Special training schools are available.
  - ◊ **Hardwood grading**
    - NHLA Inspector Training School
      Memphis, Tennessee
  - ◊ **Softwood grading (on-the-job training)**
    - Southern Pine Inspection Bureau
      Pensacola, Florida
    - Timber Products Inspection Co.
      Conyers, Georgia

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ADDITIONAL ACTIVITIES

- Display samples of hardwood and softwood boards, and have students distinguish between the types.
- Have students discuss reasons for and advantages in buying and selling graded lumber.
- Have students contact various grading associations and request copies of the rules for grading lumber.
- Prepare and distribute vocabulary sheets and have students define terms used in lumber grading.
- Invite a lumber grader to explain and demonstrate grading procedures so students can observe the process and the speed at which grading can be done.
- Have students practice lumber grading, using prescribed procedures.
- Discuss training requirements and job opportunities in the field of lumber grading. Have students save the information for use in the study of Lesson 12, "Selecting a Career."

SUGGESTIONS FOR STUDENT EVALUATION

Students should take a written test on lumber grading.

SUGGESTED RESOURCES

NHLA Grading Rules for North American Hardwoods. Memphis, Tennessee: National Hardwood Lumber Association, n.d. http://www.nhla.com/assets/1603/rules_card9.pdf

Standard Grading Rules for Southern Pine Lumber. Pensacola, Florida: Southern Pine Inspection Bureau, 2002. http://www.spib.org/publications.shtml

Typical Defects of Wood: http://www.ee.oulu.fi/~olli/Projects/Wood.Defects.html

Visual Inspection of Lumber: http://www.ee.oulu.fi/~olli/Projects/Lumber.Grading.html

Lesson

10

TEACHER NOTES

Protecting the Forest

Lesson

11

SOL CORRELATIONS

English
9.1
9.6
10.1
10.6
11.6
12.1
12.6

Civics and Economics
CE.9

Earth Science
ES.7

Biology
BIO.5
BIO.7
BIO.8
BIO.9

EQUIPMENT, SUPPLIES, AND MATERIALS

- Firefighting tools
- Instructor-prepared guidelines and checklist for evaluating protection plan

TEACHER: _____

SCHOOL: _____

GRADE LEVEL: 9–12

TASKS/COMPETENCIES

- Identify important insects, diseases, and animal pests common to area forests.
- Identify tree diseases caused by organic pathogens, insects, and the environment.
- Define the term *invasive species*.
- Explain climate effects that produce fires.
- Explain the development and anatomy of a forest wildfire.
- Describe forest wildfire fighting techniques and fire control measures.
- Prepare publicity showing how people can prevent forest and wildfires.
- Develop a forest fire protection plan.

OBJECTIVES AND GOALS

- The student should be able to describe the economic damage that occurs in state forests annually from forest fires, insects, and disease.
- The student should be able to state four rules and three laws designed to prevent forest fires.
- The student should be able to describe two methods of forest fire detection.
- The student should be able to identify facts to fight a forest fire effectively.
- The student should be able to explain the direct and indirect attack methods of fire control.
- The student should be able to describe how mechanized equipment and aircraft are used to fight forest fires.
- The student should be able to identify five harmful insects and their effects on the forest.
- The student should be able to describe three tree diseases and their symptoms.
- The student should be able to explain how livestock, deer, and mice damage the forest and how to reduce these dangers.

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ACTIVITIES

► Preparation

Lesson approach

- The importance of forest protection
- The forest in terms of economic, watershed, wildlife, recreational, and aesthetic values

General situation

- Many fires destroy forests each year in Virginia and in other parts of the United States. Forest fires can be prevented.
- Knowledge of the insects and diseases that damage forests is helpful in controlling serious outbreaks and resultant loss of timber.
- Animals may seriously damage a forest; such damage can usually be prevented if proper measures are used.

Local situation

- Information to be collected before the unit study includes
    - ◊ the number of fires that have damaged local forests during the past year
    - ◊ the number of acres of local forest burned during the past year
    - ◊ the value of forest products destroyed by fire in the local area during the past year.
- Information to be collected from students
    - ◊ the description of any fire, insect, or disease damage done to family farm or forest land
    - ◊ protective measures undertaken by students or their families.

► Application

- Have students construct a fire lane as a class project.
- Have students collect specimens of insects that attack local forests.
- Have students photograph specimens of wood damaged by each insect or disease common to the community.
- Have students observe and report on protective practices undertaken on a local farm to prevent animals from damaging the forest land.
- Have students apply for and attend Holiday Lake Forestry Camp in Appomattox.

► Presentation: Forest Protection

In the previous units, the important role that Virginia's forests play in our economy has been identified, as well as methods to establish and manage forests. For timberlands to be of the greatest value to the most people, they must be protected.

Forest fires

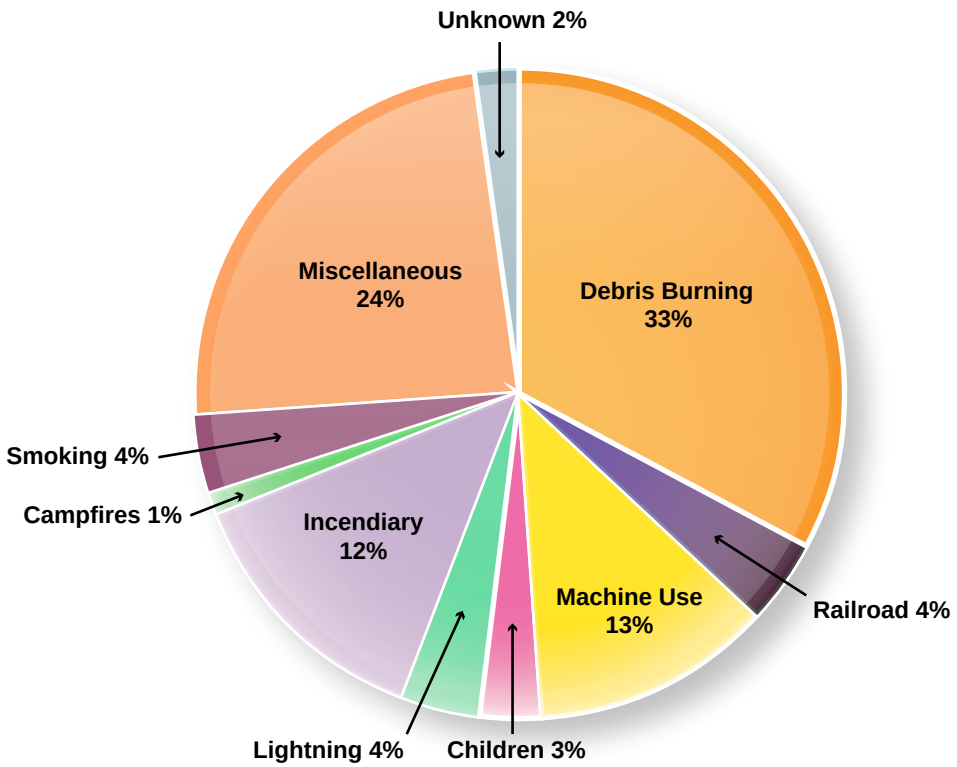
Virginia's forest fire record

The Forest Protection Team of the Virginia Department of Forestry is concerned with and responsible for the prevention, detection, and suppression of all wildfires. All department employees are involved in activities that help accomplish our goals, which are to prevent injury or loss of human life and to minimize damage to real property, timber, and other natural resources.

Records indicate that people cause most of Virginia's wildfires. Virginia is growing more rapidly than many other states, and its population has more than doubled in the last 50 years. People are moving into residential developments in forested areas, and there is an increasing use of the forests for recreation. All this increases the risk of wildfires and requires continued fire prevention and protection activities.

Virginia's wildfire season is normally in the spring (mid-February through April) and again in the fall (mid-October through November). During these times, the relative humidity is usually lower, winds tend to be higher, and the fuels are cured to the point where they will readily ignite. Also, hardwood

Causes of Wildfires in Virginia by Percentage (2002-2012)



Source: Virginia Department of Forestry

leaves are on the ground, providing more fuel and allowing sunlight to reach the forest floor directly, warming and drying the surface fuels.

As fire activity fluctuates from month to month during the year, it also varies from year to year. In some years, Virginia gets adequate rain and snow, keeping fire occurrence low. In others, the weather does not cooperate as well, and there are extended periods of warm, dry, windy, days and, therefore, increased fire activity.

Importance of keeping wildfires out of the woods

- Aside from fire consuming trees—seedlings, saplings, and pole-size—and rendering them unsellable, uncontrolled fires destroy or damage trees by killing the cambium layer, thus destroying a vital link in their food manufacturing process.
- Wildfires reduce the water-holding capacity of the soil. The leaf litter and humus form a spongy layer which soaks up the rain and snow. With the leaf litter removed, water runs off rapidly, increasing flood possibilities, and soils are easily eroded.
- Uncontrolled fires result in poor hunting and fishing. Quail eggs baked by fire will never hatch, and fish will starve in a stream choked with sediment and poisons leached from wood ashes.
- Uncontrolled fires affect the general economy. Virginia's forests are vital to the state's economy, and anything that adversely affects the forests adversely affects the whole economy.

Causes of uncontrolled fires

Note from the chart above that people are responsible for approximately 96 percent of wildfires. Because this is the case, people must be taught to be careful and should be reminded periodically of the following rules:

- Carefully extinguish campfires or warming fires – use damp earth, water, or both.
- Burn brush or trash in small piles, away from woods or dry grass, on calm, damp days.
- When using equipment/machinery during extended dry periods, watch for any sparks.

Lesson

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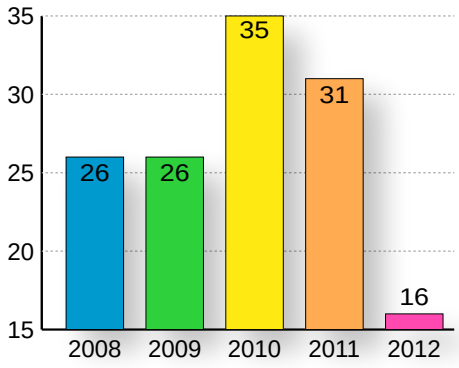
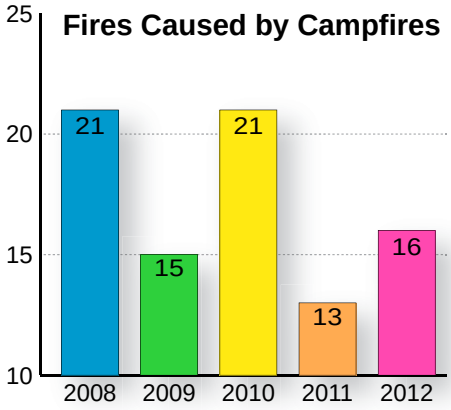
The Cause and Number of Fires in Virginia

(Source: Virginia Department of Forestry)

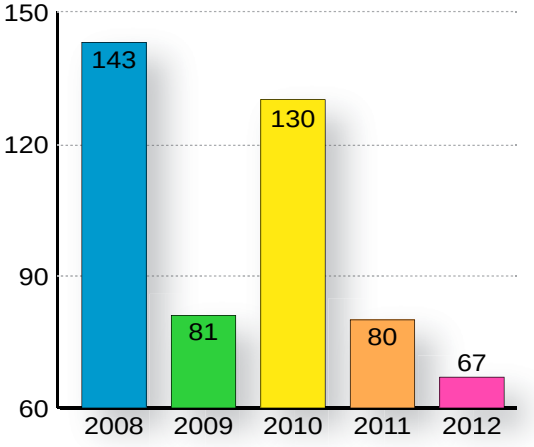
Fires Caused by Smoking



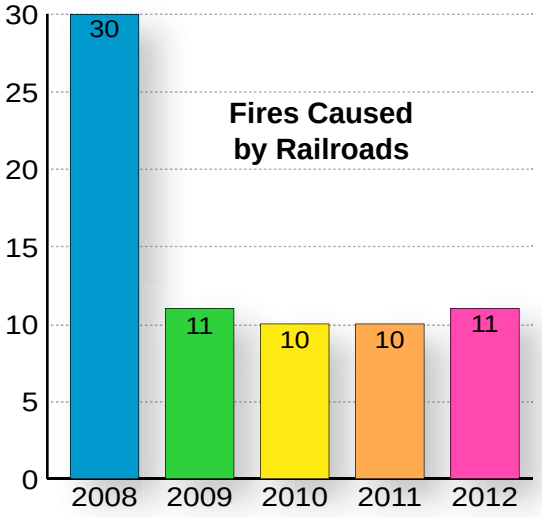
Fires Caused by Campfires



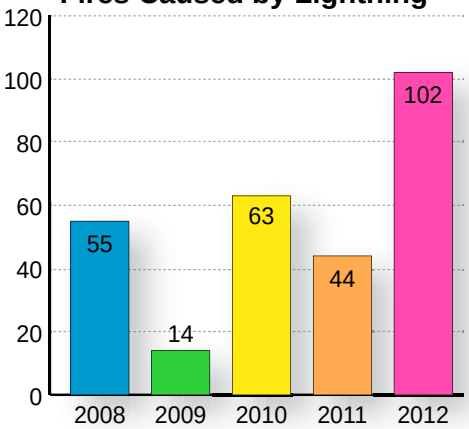
Fires Caused by Equipment



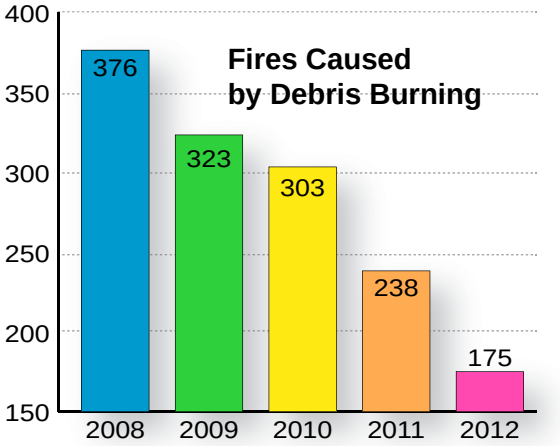
Fires Caused by Railroads



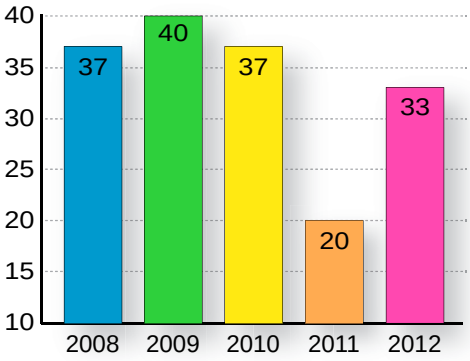
Fires Caused by Lightning



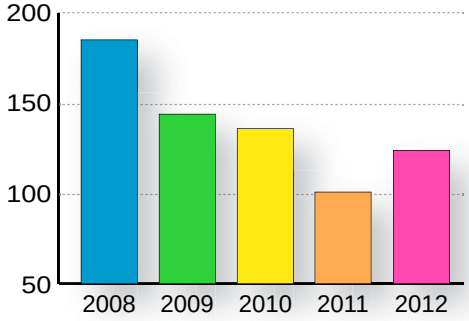
Fires Caused by Debris Burning



Fires Caused by Children



Fires Caused by Incendiary



Lesson

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Fire Detection Methods

In the early part of the 20th century, many fires were detected by the men and women who staffed lookout towers across Virginia. In the latter half of the century, airplanes replaced the fire towers. Today, most wildfires are reported by citizens who call 911 either on their cell phones or on landlines. If you spot a wildfire, try to collect as much information as possible to help in the suppression as well as the investigation of the fire's cause. Be sure to make note of any suspicious people or vehicles in the area at the time of the fire and report this to the proper authorities.

Wildland Fire Laws

Forest laws should be studied in detail. The laws are published in the State Code books and by the Virginia Department of Forestry (www.dof.virginia.gov/laws/fire-laws.htm).

Some of the laws include:

- 4 p.m. Law – From February 15 to April 30 each year, it is unlawful to have a fire within 300 feet of woods, dry grass, or brush leading to the woods, except after 4 p.m. No more fuel can be added to the fire after midnight.
- It is unlawful to leave a fire unattended if in or near the woods, dry grass, or brush leading to the woods.
- It is unlawful to toss a lighted match, cigarette, firecracker, or any burning device from a vehicle.

Actions to take when a fire gets out of control

- Notify the nearest forest warden, fire department, or sheriff's office by calling 911.
- After calling 911, make sure that people and animals are in a safe location.
- Make a note of how the fire started. This can be helpful to the forest warden.

Forest fire control techniques

Parts of a fire

- **Head:** fast-moving portion of a fire
- **Spot:** new fires set by sparks blown ahead by wind
- **Rear:** slow-moving part of a fire, usually close to the point of origin
- **Flanks:** sides of fire parallel to the direction of movement

Diagnosis of the situation:

Scout the fire for the following information:

- Location of the fire head or heads
- Types of fuel burning and types of fuel in advance of the fire
- Rate of spread of the fire
- Approximate size of the fire
- Topographical features, such as roads, streams, swamps, and hills, that may affect the fire's behavior
- Best routes for movement of workers and equipment
- Number of workers, tools, and types of equipment needed to suppress the fire

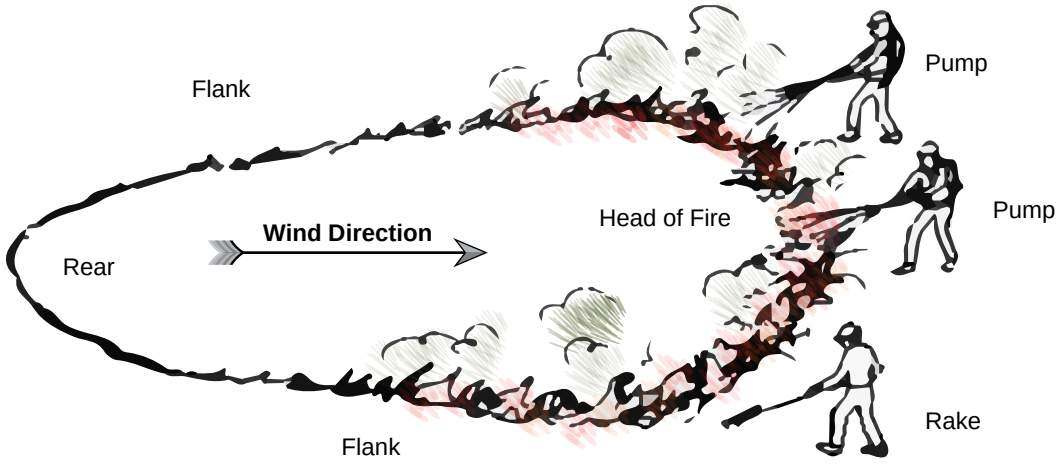
Methods of controlling a forest fire

Forest fires are usually controlled by cutting off the fuel supply. A line is built around the fire; the area burned out between the constructed line and the wildfire will remove the fuel. This is known as "burning out the line." A fire line is made by digging away all leaves, grass, and twigs (anything that will burn) down to mineral soil for a width of approximately 2 feet. Care must be taken to remove logs, roots, or any materials that will carry fire across the line. Roads, streams, and cultivated fields can serve as firebreaks.

There are two general methods used in controlling a forest fire:

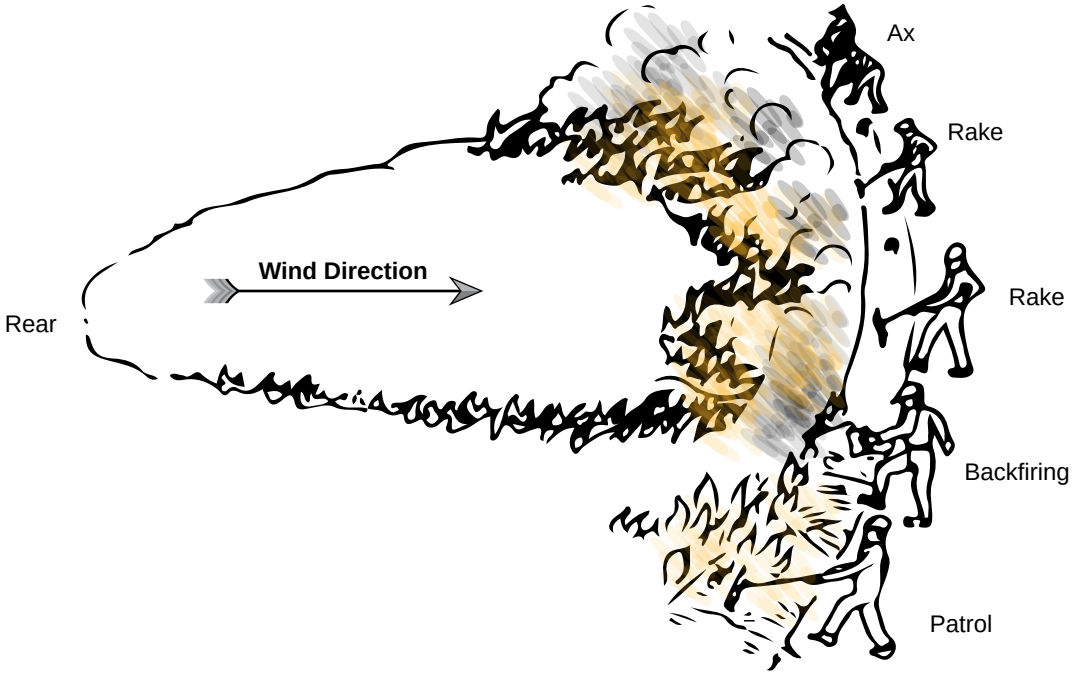
Direct attack is often used on a slow-burning fire in which firefighters can work close to the fire. The flames may be knocked down with water, earth, or a pine branch, and a fire line may be built at the edge of the fire by pushing leaves and other burnable material into the fire. A clean line must be constructed around the fire's edge to assure final control and prevent the fire from "breaking out"

later.



Indirect attack is used when the heat and rate of spread will not permit working near the flames. The following rules must be followed when locating and building fire lines:

- Stay as close as heat will permit behind the fire line.
- Do not build the line through patches of dense undergrowth. It is slow going and difficult to make safe.
- Build a fire line in front of stumps, logs, snags, and brush heaps to keep them from catching fire. They may scatter fire across the constructed line.
- Do not make sharp turns in a line.
- In hilly or mountainous country, build a line so that burning embers will not roll across fire line.
- **Caution:** Keep workers on the alert for fire crossing the line. Fire line building is hot, dirty, expensive work, and unless the line is protected, all the work is wasted.



Mechanized equipment

- **Tractor/fire plow unit:** Much firefighting is done on foot; however, mechanized equipment is necessary for transporting workers and supplies. One of the most cost-effective pieces of equipment is the tractor/fire plow unit. The plow is designed to dig a trench down to mineral soil and throw a "furrow" about four feet wide. This makes an excellent line for the line-firing or backfiring crew.
- **Aircraft:** Many techniques have been tried and continue to be developed that use aircraft

Lesson

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for fire suppression. In certain areas of the nation, large bombers are used for water drops. In Virginia, however, the present use is concentrated on water buckets slung beneath helicopters. Most sections of the state have adequate water supplies (streams, ponds, or lakes) within several minutes' flying time between the water source and the fire. The helicopter operator drops the bucket into the water supply, winches it up, and transports it to the fire. The water released is controlled by an electrically activated device in the cockpit of the helicopter.

Mopping-up operation: The job of controlling a fire is only partly completed when the line is built. The fire line must be carefully inspected and weak spots cleaned up. All burning snags near the line should be felled. Burning logs near the line should be rolled back into the fire area and covered with earth or soaked with water, and burning stumps should be covered or carefully watered. No fire is safe until every spark is extinguished.

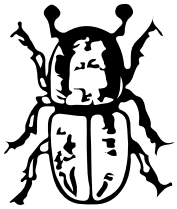
Safety: Forest firefighting is hot, dangerous work. An injured worker is of no value on the fire line. Always keep a safe working distance between workers. The tools used are sharp and dangerous. Keep an eye on the main fire and constantly check the terrain so that a safe exit can be made if the fire changes its course. The welfare and safety of the workers should have top priority in firefighting.

Forest fire control agencies

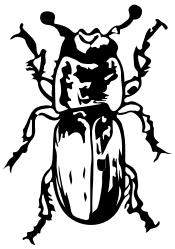
State agencies: The Virginia Department of Forestry is charged with the protection of millions of acres of state-owned and private forestland. Professional firefighters and specialized equipment are available through the regional forestry office.

All areas of the state have paid or volunteer fire departments, many of which are equipped to fight forest fires.

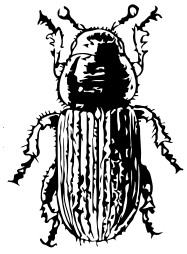
Federal agencies: The United States Forest Service has two national forests with ranger stations and forest wardens strategically located throughout. The National Park Service operates Shenandoah National Park and many smaller sites with with ranger stations and forest wardens strategically located throughout.



Ips



Southern Pine



Black Turpentine

Forest insects and diseases

Insects and disease cause timber losses by retarding growth, reducing quality, or killing the trees they attack. In addition, natural forest beauty and watershed protection may be lost when trees are killed over large areas.

Much of the insect- and disease-caused losses in Virginia can be prevented or reduced by woodland owners who have a general understanding of the habits of the more destructive pests. If trouble is noted early and help obtained from a forester, inexpensive and practical control is often possible.

A few of the most important forest insects

Bark beetles: There are many species of bark beetles, and both hardwoods and pines are subject to attack by one or more species.

In Virginia the pines are most widely and severely attacked, and outbreaks of bark beetles occasionally kill many acres of pine timber. Those attacking pine include southern pine bark beetles, Ips beetles, and turpentine beetles.

Adult bark beetles bore through the bark and construct galleries between the bark and wood, where the female lays eggs. In pine the entrance hole is usually surrounded by exuded pitch, which hardens into popcorn-like pitch tubes. These pitch tubes may occur along the entire length of the bole. Healthy trees often withstand attack by drowning the beetles with copious pitch flow; trees weakened by drought or other agents have little chance of withstanding attack.

Pine bark beetle attack is almost invariably accompanied by infection of the wood-staining fungi, which contributes to the ultimate death of the tree.

Successful attack by bark beetles can be prevented by keeping woodland trees in a vigorous and healthy condition through periodic thinning and timely harvesting. Prompt salvage of infested trees is one effective and inexpensive control method.

Gypsy moth: This pest is a native to Europe and Asia. It was introduced into Massachusetts in 1869 in an attempt to develop a hardy race of silk-producing moths. The pest escaped from the laboratory and gradually spread throughout the Northeast. By 1980, it had developed a foothold in Northern Virginia, several isolated spots in Floyd and Charlotte counties, and several other areas. In 1995, the gypsy moth defoliated more than 849,000 acres in Virginia; more recently (2009), it had defoliated about 28,800 acres.

The gypsy moth has four life stages: egg, larva (caterpillars), pupa, and adult. The damage to trees is caused by the removal of foliage by feeding caterpillars. In Virginia, the caterpillars begin feeding in late April and usually cease in early July. They then go into the pupa stage (resting state) for 10 to 17 days. Adult moths emerge and mate and the females deposit egg masses on any surface available. The egg masses overwinter and the cycle repeats.

The favored tree species for the caterpillars are the oaks and most other hardwoods. Biological controls and insecticides have had some success in controlling the gypsy moth. Outbreaks tend to occur periodically after several years of low population levels.

Pales weevil: Pine and other coniferous seedlings may be killed by this one-half inch long beetle which girdles the seedlings as it feeds on the inner bark and cambium. The pales beetle is nocturnal in habit. The weevil is attracted to areas where pine has been recently cut and, under Virginia conditions, will remain in the cut-over area for almost a year. It is a threat to pine seedlings (planted or natural) within and around such cut-over pine areas. This insect may also feed on the branch tips in Christmas tree plantations.

It is advisable to delay planting seedlings for one year in a cut-over pine woods to avoid losses. In Christmas tree plantations, freshly cut stumps may be treated with an insecticide. In forest tree plantations, when a delay in planting is impractical, it is more economical to treat seedlings by dipping them in a suspension of insecticide prior to planting.

Woodborers: Many species seldom kill a tree, but they often render it useless for high-value wood products such as furniture, veneer, and oak flooring. Losses from woodborer damage in lumber and related wood products in Southern oaks is especially severe.

There are many species of woodborers; some attack standing trees, some logs, some lumber, and a few attack wood products already in use. Wood-staining fungi are often associated with woodborer attack.

Emerald ash borer is a recent threat to Virginia's forests. This insect kills all native ash species, including healthy trees.

Pine tip moth: The larvae of the pine tip moth bore into the growing tips of young pine trees. They are particularly injurious to trees under 7 feet in height. Damage can be recognized by dead twig tips and the distorted bushy appearance of the side branches. The tree is seldom killed, but height growth is retarded. Tip moth damage is more severe in plantations on old field sites than in pines planted on cut-over areas where the soil pH is lower.

Forest tree diseases

Diseases of forest trees are generally less spectacular than insect damage, since fewer trees are killed outright. The heart-rotting fungi cause the greatest loss in timber values—exceeding the losses caused by fire, insects, animals, or weather. In Virginia, heart rots account for an estimated 80 percent of the total growth loss attributed to diseases in the forest.

Oak decline: Scarlet oak, and other species of oak to a lesser extent, periodically suffer extensive die-

back and death during periods of prolonged drought. Insect defoliation and shallow soils have contributed to this extensive decline over thousands of acres in the western third of the state. Salvage and sale of the affected timber is the only method currently available to reduce dollar losses.

Heart rots: Wood-decaying fungi can enter trees through various wounds, old branch stub scars, or from the parent stump in the case of sprout growth. Large scars (even if healed), bleeding, abnormal swelling along the trunk, or the presence of conks or toadstools of the rot fungus are indicators of decay. Defective trees should be cut and sold to salvage value remaining; non-saleable defective trees should be poisoned or felled to make room for unaffected neighbors.

Oak wilt: A potentially serious threat to the oak forests of Virginia, this wilt fungus causes infected red oaks to exhibit characteristic symptoms including premature discoloration and extensive leaf fall in early summer (many fallen leaves are still green). Positive diagnosis can be made through laboratory testing by the Virginia Department of Forestry. An annual aerial survey by the Department of Forestry keeps tabs on the intensity and spread of this disease.

Animals as damaging agents to forests

Livestock

Woodlands at best make poor pasture. Livestock damage the woods by eating and trampling the young hardwood seedlings and sprouts and by packing the soil so that air and moisture are kept out. The trampling of roots or larger trees also is detrimental. Livestock grazing of woods is detrimental especially in the Piedmont and mountain forests of the state. If shade is needed for livestock, a small area of the woods should be fenced off for their use.

Other animal pests

Mice are especially damaging to young plantations, because they strip the bark from the bases of seedlings. If a heavy mouse population is suspected, control measures should be taken.

Deer are a serious pest in many parts of the state, particularly where hardwoods are being established. Deer browsing can alter the entire forest understory, leading to poor hardwood reproduction and decimation of other beneficial understory plants. In riparian and urban areas where hardwood seedlings are planted, tree shelters can be used to protect individual trees until they are large enough to withstand some level of browsing.

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ADDITIONAL ACTIVITIES

- Display graphs and charts citing forest fire statistics, and have students investigate the cause of the most destructive fires from 1918 to the present.
- Have students discuss the effect of forest fires, insects, and disease on the state and local economy. If there are woods in the local area recently damaged by fire or widespread disease, arrange to have students visit the site. Ask them to estimate the different sources of income lost through the damage.
- Have students create a digital slideshow on fire prevention rules and laws.
- Have students explain the use of common tools in fire control.
- Display pictures of insects harmful to trees, and have students contact a local forester or conduct online research into the control of these insects.

SUGGESTIONS FOR STUDENT EVALUATION

Students should construct a forest protection plan. Evaluate according to the teacher's checklist.

SUGGESTED RESOURCES

Tree Disease and Insect Guide for Hardwoods: http://www.dof.virginia.gov/health/guide/insect-disease-guide-hardwood.htm

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TEACHER NOTES

Lesson

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SOL CORRELATIONS

English
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9.8
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12.1
12.6

Civics and Economics
CE.12

EQUIPMENT, SUPPLIES, AND MATERIALS

- Instructor-prepared research guidelines
- College and training institute catalogs
- Online access

Selecting a Career

TEACHER: _____

SCHOOL: _____

GRADE LEVEL: 9–12

TASKS/COMPETENCIES

- Define terms related to the nature, scope, and importance of a forestry career.
- Identify career opportunities available in forestry.
- Participate in a career exploratory activity.
- Write a report on occupations in forestry.

OBJECTIVES AND GOALS

- The student should be able to identify unskilled, semi-skilled, skilled, technical, and professional jobs related to forestry.
- The student should be able to define job title, job duties, working conditions, projected employment outlook, entry-level, and advancement opportunities.
- The student should be able to conduct research and obtain information that can be secured from the Dictionary of Occupational Titles, Occupational Outlook Handbook, and other selected references.
- The student should be able to identify criteria for an effective presentation of findings.

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ACTIVITIES

► Preparation

Lesson approach

The growing, harvesting, processing, and marketing of forest products involves a large percentage of the national working population. One in every nine workers engaged in manufacturing works directly with wood.

Wood in some form is used by everyone almost every day. The American economy could not exist without a continuous flow of wood and other products from the forest through the factories and to consumers. To maintain a constant flow of forest products and to assist people in obtaining the benefits provided by the forest, forestry and related industries require personnel trained in a multitude of different skills.

In addition to employment connected directly with the forest and its allied industries, there are many other jobs that involve products from the forest. Of growing importance are wildlife management and outdoor recreation careers, which involve employment opportunities for semi-skilled and skilled workers, technicians, and professional personnel.

Multiple-use forestry and wood-using industries employ people in many correlative jobs: writers, photographers, salespeople, trappers, timber cruisers, scaler guides, fire wardens, conservation officers, and surveyors. Young people who want to work outdoors or in some phase of forest resource can find job opportunities appealing to their special interests.

Many jobs in the field require vocational training; some require a technical school or college education. There are also opportunities for the high school graduate to advance through experience and on-the-job training.

General situation

Of the land area in the United States, 751 million acres, or about 33 percent, is forest.

National and state forests are managed for the many products and value that can be obtained from them. While industry, farm, and other private ownerships are more likely to be managed for timber products alone, the trend is for them to be managed for related uses also.

As the amount of forestland is reduced due to demands for other uses, the intensity of management and the need for professional and technical help will increase.

State situation

Of Virginia's land area, 62 percent is covered in forest. Virginia forests are presently producing at about one-third of their potential. While the productivity of these forests is increasing, there is still a need for good forest management.

Further information, facts, and figures on Virginia's forests and forest economy can be found in *The Economic Impacts of Agriculture and Forest Industries in Virginia*, by Terrance J. Rephann of the Weldon Cooper Center for Public Service at the University of Virginia.

Local situation

There are some forest-related industries in every region of Virginia. Prior to unit study, the instructor should identify as many forestry-related job titles available in the local area as possible and divide these titles into unskilled, semi-skilled, skilled, technical, and professional categories.

Lesson

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► Application

- Based on the previous units of study, have students list the types of work involved in managing a forest, a wood-processing plant, or a wood-using industry; then have them prepare a similar list that involves the management of forest-related natural resources for wildlife and recreational use.
- After all students have presented their oral reports on selected careers to the class, have each student participate in a discussion identifying careers that meet their personal aptitudes, interests, and goals.
- Have students investigate sources of training or education required for their selected careers by using catalogs to determine entrance requirements and courses offered.

► Presentation: Forestry Careers

Introduction to forestry careers

Today, forestry is more than fire protection and the growing of trees. Other products and benefits of the forest, such as water, wildlife, forage, and recreation are becoming more important as our population increases.

New products and new production methods demand new skills for which training is being provided by career and technical education schools and colleges of forestry. These new jobs, both in the woods and in the factories, represent a variety of pioneering efforts that can be a challenge to everyone in forestry.

Jobs in forestry and related fields range from semi-skilled labor, for which training may be obtained in a secondary school program, to positions that require training beyond a four-year college degree.

Training required for selected forestry occupations

Unskilled: These jobs consist mostly of physical labor and require no specific education or training; they are in limited supply and many are being replaced by machines:

- Brush cutter
- Lumber piler
- Pulpwood piler
- Road worker

Semi-skilled: These jobs require a high school education with training in forestry; in addition, they require decision-making skills and independent action and may lead to skilled occupations:

- Equipment operator
- Fire dispatcher
- Log scaler
- Park guard
- Sawmill machine operator
- Surveyor assistant
- Timber marker

Skilled: Skilled job categories require specialized training beyond high school, which in some cases can be fulfilled by on-the-job training. Many job opportunities exist in these areas:

- Dry kiln operator
- Supervisor—mill, nursery, woods, yard
- Head sawyer
- Lumber grader
- Master mechanic
- Tree surgeon

Technical: These rapidly growing fields require a high school education plus one or more years of formal technical training; a year or more in a semi-skilled or skilled job can make formal study more meaningful:

- Computer operator
- Forest road designer

- Radio technician
- Research assistant
- Timber cruiser

Professional: These occupations require a four-year college degree at a minimum. Success in these jobs leads to advancement beyond the specialties into administrative positions in industry, government, and high-level leadership positions:

- Fire control officer
- Forest entomologist
- Forest pathologist
- Forest soils scientist
- Forest superintendent
- Forestry instructor
- State or federal agency forester
- Consulting forester
- Wildlife manager
- Wildlife biologist

Employment in the wood-using industry

In contrast to the United States as a whole, where employment in the wood-using industry is approximately 10 percent of all those engaged in manufacturing, in Virginia about one in six workers is employed in this field. With nearly two-thirds of Virginia land in forest, wood-using industries cover a wide range of products—furniture, paper, veneers, plywood, and particle board. Most jobs in the wood-using industry are semi-skilled, skilled, or professional.

Employers

Both private industries and public or governmental agencies employ workers in forestry-related occupations, mostly on the technical and professional levels. Many professional foresters are self-employed as consultants who help private landowners meet their management goals.

Lesson

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ADDITIONAL ACTIVITIES

- Introduce students to available references on forestry-related careers, discuss types of data contained in each, and demonstrate how to use each reference for research.
- Have students define terms concerned with careers in forestry and related research.
- Invite selected persons employed by various local forest industries to talk about their jobs to the class.
- Invite the school counselor to speak with the class about various aptitude and interest surveys available to students searching for occupational goals.
- Have students conduct online research into private and public postsecondary schools that offer a forestry curriculum, and provide time for students to report on their findings.
- Discuss and demonstrate how to make an effective presentation. Have students develop an evaluation checklist that includes the elements of good public speaking; if desired, have students evaluate presentations according to the checklist.
- Have students conduct online research on forestry careers and report to the class about one specific forestry career of their choice.

SUGGESTIONS FOR STUDENT EVALUATION

The presentations on selected careers should be presented to the class. If desired, the reports can be evaluated by means of the student-developed checklist.

SUGGESTED RESOURCES

Farming, Fishing, and Forestry Occupations (Major Group): Occupational Employment and Wages. Occupational Employment Statistics, U.S. Bureau of Labor Statistics. May 2012: http://www.bls.gov/oes/current/oes450000.htm

Rephann, Terance J. *The Economic Impacts of Agriculture and Forest Industries in Virginia*. October 2013. Charlottesville: Weldon Cooper Center for Public Service.

Rephann, Terance J. Presentation: The Economic Impacts of Forestry in Virginia. October 2013. Charlottesville: Weldon Cooper Center for Public Service.

Lesson

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TEACHER NOTES

Appendix A:

Plans for a Tree Planting Bar

Materials needed

Handles: 6½ inch threaded ¾-inch pipe

Tee: ¾-inch

Shaft: ¾-inch, threaded on both ends. This arrangement permits changing the length of the bar to accommodate the user.

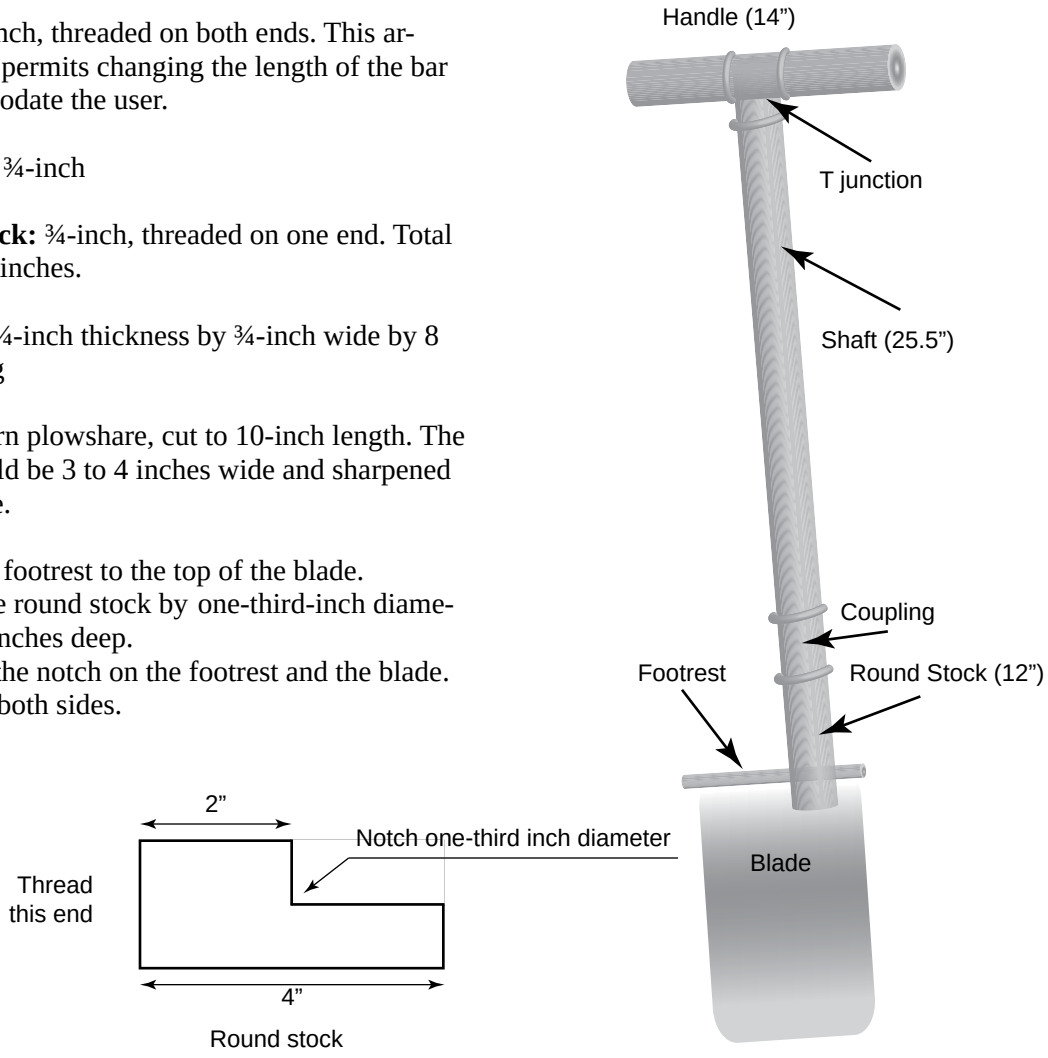
Coupling: ¾-inch

Round stock: ¾-inch, threaded on one end. Total length is 4 inches.

Footrest: ¼-inch thickness by ¾-inch wide by 8 inches long

Blade: worn plowshare, cut to 10-inch length. The blade should be 3 to 4 inches wide and sharpened on one side.

- Weld the footrest to the top of the blade.
- Notch the round stock by one-third-inch diameter by 2 inches deep.
- Overlap the notch on the footrest and the blade.
- Weld on both sides.



Appendix B:

Publication 58: Tables for Measuring Timber

TABLES FOR MEASURING TIMBER

Virginia Department of Forestry

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Publication Number 58

TREE SCALE IN BOARD FEET

International Rule ¼ inch Saw Kerf

Form Class 79

DIAMETER BREAST HIGH (inches)	NUMBER OF 16-FOOT LOGS								
	1	1½	2	2½	3	3½	4	4½	5
	Volume in Board Feet, International ¼ inch Rule								
8	20	27	33	38					
10	38	50	61	69	77				
12	58	77	96	110	124	132	141		
14	82	110	138	160	182	196	211		
16	108	146	183	214	246	269	292		
18	140	190	240	282	325	356	388		
20	176	240	305	360	414	455	496	528	561
22	216	297	378	446	514	568	621	666	710
24	260	359	458	543	628	690	753	814	875
26	305	422	540	641	742	820	899	972	1046
28	357	496	635	756	877	969	1061	1152	1242
30	413	575	737	878	1020	1128	1235	1346	1458
32	474	661	848	1014	1181	1310	1440	1562	1685
34	538	752	966	1158	1349	1498	1647	1790	1932
36	602	844	1087	1304	1521	1690	1860	2024	2189
38	674	947	1220	1470	1720	1910	2101	2294	2488
40	750	1058	1365	1644	1923	2142	2362	2568	2775

For average timber, use the volumes shown.

When form class is different from 79, add or subtract 3% of total volume for each unit increase or decrease in form class.

LOG SCALE

International Rule ¼ inch Saw Kerf

DIAMETER* OF LOG SMALL END (inches)	LENGTH OF LOG (FEET)				
	8	10	12	14	16
	Volume in Board Feet				
5	5	5	9	10	13
6	9	10	13	15	20
7	13	15	20	25	30
8	18	22	25	35	40
9	22	30	35	45	50
10	30	35	45	55	65
11	35	45	55	70	80
12	45	55	70	85	95
13	55	70	85	100	115
14	65	80	100	115	135
15	75	95	115	135	160
16	85	110	130	155	180
17	95	125	150	180	205
18	110	140	170	200	230
19	125	155	190	225	260
20	135	175	210	250	290
21	155	195	235	280	320
22	170	215	260	305	355
23	185	235	285	335	390
24	205	255	310	370	425
25	220	280	340	400	460
26	240	305	370	435	500
27	260	330	400	470	540
28	280	355	430	510	585
29	305	385	465	545	630
30	325	410	495	585	675

*** Diameter of log is taken inside of bark at small end.**

TREE SCALE FOR PULPWOOD

Cubic-foot* Volume Table Including Bark

For Average Second-Growth Southern Pine

DIAMETER BREAST HIGH (inches)	NUMBER OF 5-FOOT BOLTS											
	1	2	3	4	5	6	7	8	9	10	11	12
	Volume in Cubic Feet (including bark)											
4	0.436	0.720	1.00									
5	0.845	1.25	1.65	2.05	2.46	2.86						
6		1.82	2.38	2.94	3.49	4.05	4.61	5.16	5.72			
7			3.20	3.94	4.68	5.43	6.17	6.92	7.66			
8			4.09	5.06	6.03	6.99	7.96	8.93	9.89	10.9	11.8	12.8
9				6.30	7.52	8.75	9.97	11.2	12.4	13.6	14.9	16.1
10				7.66	9.17	10.7	12.2	13.7	15.2	16.7	18.3	19.8
11				9.13	11.0	12.8	14.7	16.5	18.3	20.2	22.0	23.9
12				10.7	12.9	15.1	17.3	19.5	21.7	23.9	26.1	28.3
13				12.4	15.0	17.6	20.2	22.8	25.4	28.0	30.6	33.2
14				14.3	17.3	20.3	23.3	26.4	29.4	32.4	35.5	38.5
15							26.7	30.2	33.7	37.2	40.7	44.2
16							30.3	34.2	38.2	42.2	46.2	50.2

* To convert the cubic-foot volume of the standing trees to stacked cords or units, divide by:

90 for 128 cubic ft. cord (4'x4'x8') **112 for 160 cubic ft. unit** (4'x5'x8') **126 for 180 cubic ft. unit** (4½'x5'x8)

The converting factors take into account the air space that occurs between the stacked wood bolts.

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