2026

NCF-ENVIROTHON MISSISSIPPI

STUDY RESOURCES

ENVIROTHON MISSISSIPPI 2026

FORESTRY

2026

Forestry Ecology

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Any hyperlinks included in the study resources, apart from those explicitly listed as Resources on the Key Topics page and featuring a dedicated page in the resources (such as YouTube videos), are considered supplemental material ONLY. While they can provide extra information, they are not mandatory study resources.

NCF-Envirothon 2026 Mississippi

Forestry Study Resources

Key Topic #1: Plant Biology

1. Explain the fundamentals of plant biology as they apply to trees and other common plants, including:
    a. Anatomy
    b. Life cycles
    c. Reproduction
    d. Growth habits
    e. Adaptations
2. Explain the formation and function of different types of tissues found in trees and other plants (including xylem, phloem, cambium, cuticle, stomata, vascular bundle, apical meristem, and lateral meristem).
3. Describe the different types of leaves and their evolutionary advantages.
4. Identify the differences between the following: angiosperm, gymnosperm, deciduous, coniferous, evergreen, hardwood, and softwood.
5. Describe how tree rings form, and how they are used in dendrochronology.

Resource Title	**Source**	**Located on Page**
What is Dendrochronology?	*Part 1: What is dendrochronology? (n.d.). TREX Tree-Ring Expeditions Labs.* https://serc.carleton.edu/trex/students/labs/part_1xxxx.html	4
Tree Parts	*Tree Parts (2025, March 11). Texas A&M Forest Service.* https://tfsweb.tamu.edu/elibrary-item/tree-parts-2/	7
Scientific Classification of Trees	*Reeb, J. E. (n.d.). Classification and naming of trees. University of Kentucky [Report].* https://publications.mgcafe.uky.edu/files/for61.pdf	8
The Five Major Types of Biomes	*The Five Major Types of Biomes. (n.d.).* https://education.nationalgeographic.org/resource/five-major-types-biomes/	11
Tree Health Assessment and Risk Management	*Mississippi State University Extension Service. (n.d.). Tree health assessment and risk management.* https://extension.msstate.edu/sites/default/files	15
Fusiform Rust in Arkansas	*Barry, J. E., Kirkpatrick, T. L., & Cunningham, K. (n.d.). Fusiform Rust in Arkansas. University of Arkansas [Report].* https://www.uaex.uada.edu/publications/pdf/FSA-7543.pdf	25

Note: This work is under development but has been released temporarily for classroom testing purposes.

Part 1 - What is Dendrochronology?

A Brief History

In the late 1800s and early 1900s, Andrew. E. Douglass founded the science of dendrochronology — the technique of dating events, environmental change, and archaeological artifacts by using the characteristic patterns of annual growth rings in timber and tree trunks. As a young astronomer working at the Lowell Observatory in Arizona, Douglass had a particular interest in the sun, especially the cyclic behavior of sun spots and how the sun influences weather. He began looking at the annual growth rings of trees and noticed a relationship between the size of the growth rings and climate factors such as moisture and elevation. He plotted the width of tree rings and compiled the first chronologies to show how trees record climate changes through time. Noting the similarity in the response of trees across the region, he invented a technique that would prove to be a fundamental tool in tree-rings studies: **cross-dating**is a technique that ensures each individual tree ring is assigned its exact year of formation by matching patterns of wide and narrow rings between cores from the same tree, and between trees from different locations, or matching the patterns of tree rings from one tree to another. This allowed scientists to mark exact calendar dates for each ring. Today, tree-ring analysis is not only used to determine what the climate was like in the past, it can also be used to date works of art (wooden frames), violins and other wood instruments, and buildings.

To see the process of cross-dating in action, watch historical footage of A.E. Douglas at work.

Tree-Ring Basics

Trees typically grow one ring per year. They start growing in the spring (the cells are light tan in color, known as **early wood**is the light colored portion of a tree ring produced in the spring) and, as the growing season ends in the fall, the cell walls thicken (the dark band or **late wood**is the darker part of an annual tree ring produced in the summer season) and eventually stop growing in the winter causing a very distinct ring. The ring pattern that forms over the entire life of the tree reveals the climatic conditions in which the tree grew. Abundant moisture and a long growing season result in a wide ring. A dry year may result in a very narrow ring (see diagram). At sites where trees are more sensitive to temperature (e.g. at high altitude on a mountain top or in the **boreal**of the north or northern regions forests of northern Alaska and Canada) then a wide ring indicates a warm year and a narrow ring indicates a cold year.

In this activity, you will learn how tree-ring science is done. Where do tree-ring scientists travel to to find suitable trees? What tools are used? What techniques can be used to prepare and analyze tree core samples to reveal the nature of past climate?

Instructions

1. Finding Climate Sensitive Trees

Conducting tree-ring science isn't as simple as it might first appear. The vast majority of trees we see on hikes or while driving will not have captured a good climate record over long periods of time. Dendrochronologists need to search for long-lived trees that grow in fairly harsh environments, making them very sensitive to the surrounding conditions, where their growth is slow— so slow that many years will be recorded in their lifetimes. One such tree is the bristlecone pine, which grows in Utah, Nevada and eastern California. The oldest known specimen is named Methuselah and is a 4,765 years old! You'll have a chance to explore a bristlecone pine site in Part 2 of this lab.

What characteristics do dendrochronologists look for in research sites that will give them the best chance to reconstruct past climatic conditions? Watch the video below and answer the *Stop and Think* questions.

Stop and Think

1.1 What types of trees and tree-ring sites are the most useful for tree-ring research?

1.2 Why are trees growing in landscaped areas not useful to study past climate conditions?

1.3 What governs the rate of tree growth at high altitudes?

2. Coring Trees

Now let's learn how to obtain tree cores samples from a tree. People often ask if drilling into the tree to take a sample of its wood harms it. The core samples that scientists take from trees are actually quite small (less than the diameter of a pencil) and non-destructive to the tree. The tree will heal itself fairly quickly, similar to when a spout is removed after tapping a tree for maple syrup. If there is concern for a particular group of trees, scientists can dip their tree borers into alcohol to be sure they are not spreading any diseases from tree to tree. If forest managers are concerned for a particular forest, they can deny scientists permission to core trees when they apply for a permit.

Watch dendrochronologist Nicole Davi describe how to core a tree.

WATCH: Nicole Davi cores a tulip tree with assistant Augie. Credit: Jacob Tanenbaum (MP4 Video 268.2MB Mar28 16)

3. Processing the Cores

Scientists collect core samples from twenty or more trees at each of their sites. These samples need to be carefully contained and brought into a laboratory for analysis. Cores taken from a tree need to be mounted in a special wooden holder, or core mount, and then finely sanded to bring out the ring pattern clearly.

Tree cores taken from white spruce trees in Alaska. These cores have been placed in wooden core mounts and finely sanded so that cell detail is visible under a microscope. Each ring represents one year of growth. The wide rings indicate good growing conditions (warmer summers in this case).

Tree-ring patterns are then studied with a number of different scientific instruments. The buttons below will take you to the Lamont-Doherty Earth Observatory's Tree-Ring Lab in Palisades, New York. These images are 360 °, so you can look around and zoom in and out. Zoom in to both the main work area and the core room so you can see what's on the tables and walls.

Tree-Ring Laboratory

Tree-Ring Laboratory Core Room

Stop and Think

1.4 Why is one part of each tree ring light in color and the other part dark in color?

1.5 What factors did Dr. Davi consider in choosing a good tree to core at her location in the woods?

1.6 What instruments did you see in your tour of the Lamont Tree-Ring Lab?

1.7 What kind of specimens did you see in the core room?

IMPORTANT NOTE: At the conclusion of the lab, please take a few minutes and complete a short Student Survey. Your feedback is extremely important as we try to improve the quality of our materials.

Tree Parts

1. Crown: (head) part of the tree that consists of the leaves and the branches at the top of a tree.

2. Leaves: (fingers) food factories of the tree. The leaves contain chlorophyll which gives leaves their green color and is responsible for photosynthesis. During photosynthesis, leaves use solar energy from the sun to transform carbon dioxide from the atmosphere and water from the soil into sugar and oxygen producing a chemical change. The sugar (which is the tree's food) is either used or stored in the branches, in the trunk, or in the roots. The oxygen is released into the atmosphere. Leaves clean the air and use energy from the sun to produce food for the tree.

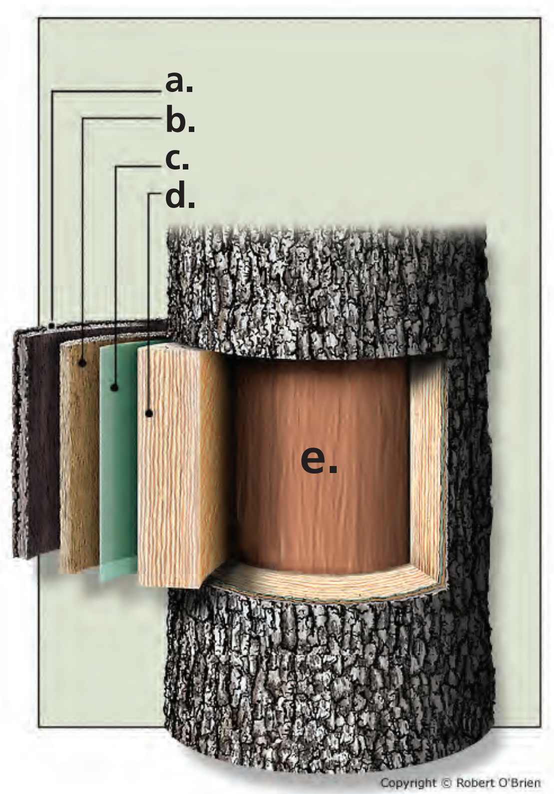
3. Branch, Twigs and Boughs: (arms) A branch is a woody part of the tree connected to, but not part of the central trunk. Large branches are known as boughs and small branches are known as twigs.

4. Flowers and Seeds: Flowers produce seeds. Seeds are the primary way that trees produce new trees. Seeds vary greatly in size and shape.

5. Trunk: Provides support and is used as "pipes" to transport nutrients to the leaves and sugar from the leaves to the rest of the tree.

Parts of the Trunk are

- **a. Bark:** (skin) protects the tree from injury by animals, diseases, fire, etc. and has a variety of characteristics such as thin, thick, spongy, rough, smooth.
- **b. Inner Bark or Phloem:** (arteries) inner bark that carries sap from leaves to rest of tree.
- **c. Cambium:** (veins or artery tissue) a thin layer of growing tissue between the xylem and phloem.
- **d. Sapwood or Xylem:** (veins) brings water and nutrients up from the tree roots.
- **e. Heartwood:** (skeleton) forms the core, is made of deadwood and provides strength.



6. Roots: (feet) holds the soil in place, anchor the tree in the ground and absorb water and nutrients from the ground. The roots include lateral roots, rootlets and root hairs.

TREE TRAILS

COOPERATIVE EXTENSION SERVICE
UNIVERSITY OF KENTUCKY • COLLEGE OF AGRICULTURE

SCIENTIFIC CLASSIFICATION OF TREES: *An Introduction for Wood Workers*

James E. Reeb, Extension Specialist, Department of Forestry

Introduction

Those who work with wood should be able to distinguish between different woods and be familiar with features that make different kinds of wood react differently to cutting, surfacing, finishing, etc. An obvious first step in accomplishing these tasks is to be able to properly identify and name an unknown wood. It is helpful in identifying wood to know that trees, as well as other living organisms, are assigned to groups based on similar physical characteristics.

This publication will introduce the reader to the science of taxonomy, that is, the practice of classifying and assigning living things to groups based on their similarities in anatomical structures. Scientists use scientific names to signify into what groups living things belong.

The users of wood should be familiar with the fact that common names can often be misleading and that the wood of some trees with similar common names may actually be quite different in their structures and properties. Scientific names eliminate the confusion that can occur when using common names.

Common Names Often Misleading

Most probably, each kind of tree in the United States has more than one common name. When G. B. Sudworth, a United States Forest Service employee, published a checklist of trees in 1927, he included about 1,000 trees; however, the list also included almost 9,000 common names as local describers of these trees.

For most practical purposes, common names can be used with no problem. However, in some cases, common names can be confusing or misleading. One kind of tree may be referred to by several different common names throughout its natural growing range. A single name may refer to more than one kind of tree. For example, the term "scrub oak" is often used when speaking about post oak, blackjack oak, and other "scrubby looking" oaks found in the southwestern United States. The tree we commonly call the yellow poplar is not a true poplar, such as cottonwood and aspen, but is instead a member of the magnolia family, *Magnoliaceae.* Eastern redcedar is actually a juniper and not a true cedar.

Common names may describe where the tree grows, such as swamp white oak and river birch, or how the tree looks, such as weeping willow and quaking aspen.

Other common names describe the use of the tree, such as sugar maple and canoe birch. Another way to assign a common name to trees is to incorporate the discoverer's name in the tree name, such as Nuttal oak and Douglas-fir.

Classification and Naming of Trees

Organisms are assigned scientific names because of the confusion of using common names and because of the many different languages spoken throughout the world. Scientists have settled primarily on Latin for scientific names, although they sometimes use Greek or other languages. The important thing is that, regardless of the language the scientist uses for communication, the scientific names chosen for all classified living organisms are the same worldwide. Classifying and assigning scientific names also include those organisms that once lived, such as the dinosaurs.

You may wish to refer to Figure 1 for the following explanation of the classification of trees. The highest taxonomic division of living things is the **kingdom.** All living organisms are placed in either the plant kingdom or the animal kingdom. Since this publication is about the classification of trees, only the taxonomy of the plant kingdom, and specifically trees, will be discussed. However, the taxonomic classification of other plants, and that of animals, is very similar.

The plant kingdom is further classified into **divisions.** Trees are included in the division *Spermatophyta.* Spermatophytes include all plants that have seeds. Divisions are further broken down into **subdivisions**. Spermatophytes are divided into two subdivisions, *Angiospermae* (encased seeds) and *Gymnospermae* (naked seeds). Trees are included in both of these subdivisions.

Trees often referred to as broad-leaved hardwood trees are included in the subdivision *Angiospermae.* Angiosperms have a specialized organ of reproduction, the flower. The term angiosperm refers to the presence of an ovary that encloses the ovules or seeds. The ovary is the fruit found on the tree. Examples of fruit found on hardwood trees are the samara (wings) of the maples and ashes, the acorn of the oaks, the nut of the hickories, the pome of the apples, the drupe of the cherries, and the berry of the persimmon tree.

Angiosperms are further divided into two **classes,** *Monocotyledoneae* and *Dicotyledoneae.* Monocots have one initial seed leaf and dicots have two. There are no commercially important monocot trees in the United States. Three groups of monocots that attain large size and produce woody stems are bamboo, palm, and rattan. Furniture, fishing rods, and other small items made from these woods are often imported into the United States. Although they produce woody stems, the anatomy of monocots is quite different from that of dicots.

Trees that produce hardwood lumber belong in the class *Dicotyledoneae.* Dicot trees in the United States are divided into twenty-five **families.** All the important hardwood species found in the United States are represented within these families. Examples are *Salicaceae,* the willows and poplars, and *Fagaceae,* the beech family that includes the oaks, American chestnut, chinkapin, and others. In Figure 1, black walnut is shown to be included in the family *Juglandaceae.*

The subdivision *Gymnospermae* includes all the trees that we commonly call softwoods. Softwoods fall within four families of the **order** *Coniferales*, the conifers. The four families are *Cupressaceae*, cedars, junipers, and cypress; *Taxaceae*, yews; *Taxodiaceae*, redwood and baldcypress; and *Pinaceae*, pines, firs, hemlocks, spruces, and larches. The term conifer refers to the fruit that in some (but not all) conifers is a cone.

Genus and Species

Genus is a subgroup of organisms that have many common characteristics. Genus can be thought of as a generic name, such as oaks, willows, or pines. A tree **species** (both singular and plural) can be thought of as a specific kind of tree. A more technical definition of a species is organisms that are similar in anatomical form and structure that can interbreed to produce fertile offspring of the species. There are many different species of oaks, willows, and pines.

What is the Best Name?

A preferred common name for a tree, and its wood, would be one that included some reference to both its genus and its species. Examples are *Quercus alba* and *Acer saccharum. Quercus* is the genus for oaks, and *alba* is the Latin word for white. The common name, white oak, describes the scientific name *Quercus alba. Acer* is the genus for maples, and *saccharum* is the Latin word for sweet or sugar. The common name, sugar maple, describes the scientific name *Acer saccharum.* However, white oak also describes a grouping of several species of oaks that can be separated by both tree and wood characteristics from another grouping of several species of oaks referred to as red or black oaks.

Because *nigra* is Latin for dark or black, one would suspect *Quercus nigra* to be black oak, but that tree's most used common name is water oak. Black oak's scientific name is *Quercus velutina.* The Latin word *velutum* means velvety. Black oak leaves are exceedingly lustrous, dark green, and velvety. A better common name for this species might have been velvet-leaved oak or velvet oak. Again, black oaks or red oaks may also refer to a group of oaks that can be separated from the white oak group.

This type of confusion is the reason scientists and others use scientific names when referring to different species of organisms. Figure 1 illustrates how black walnut (*Juglans nigra*), a commercially important hardwood, is classified. Other trees in the world may have the common name black walnut, but only this tree is recognized with the scientific classification illustrated in Figure 1. For most practical purposes, common names, especially when used within one area or region, are sufficient to identify tree or wood species. But remember, there can be confusion when using common names to describe a tree or its wood.

How Many Kinds of Trees?

There are close to 10,000 identified species of trees on the earth. Of these, only about 500 are softwoods. It is estimated that hardwoods make up about twice the volume of softwoods in the world. There are more than 1,000 different species of trees in the United States. Of these, about 80 species are recognized as being commercially important for their wood. These are made up of about 30 softwoods and about 50 hardwoods. Although not commercially important for their wood, some trees have value as yard trees or ornamentals, for nut and other fruit production, or for the chemicals they produce. For example, the bark of the Pacific yew (*Taxus brevifolia*), a gymnosperm or softwood, has recently gained importance as a source for taxol, an anti-cancer chemical. An example of a popular ornamental yard tree is the ginkgo (*Ginkgo biloba*), another gymnosperm. This tree is used extensively in the United States as an ornamental and has proven to be very resistant to insects, disease, pollution, and drought.

For more information on classifying or identifying trees or woods, contact your county Cooperative Extension Agent, a Kentucky Division of Forestry forester or a specialist at the Department of Forestry at the University of Kentucky.

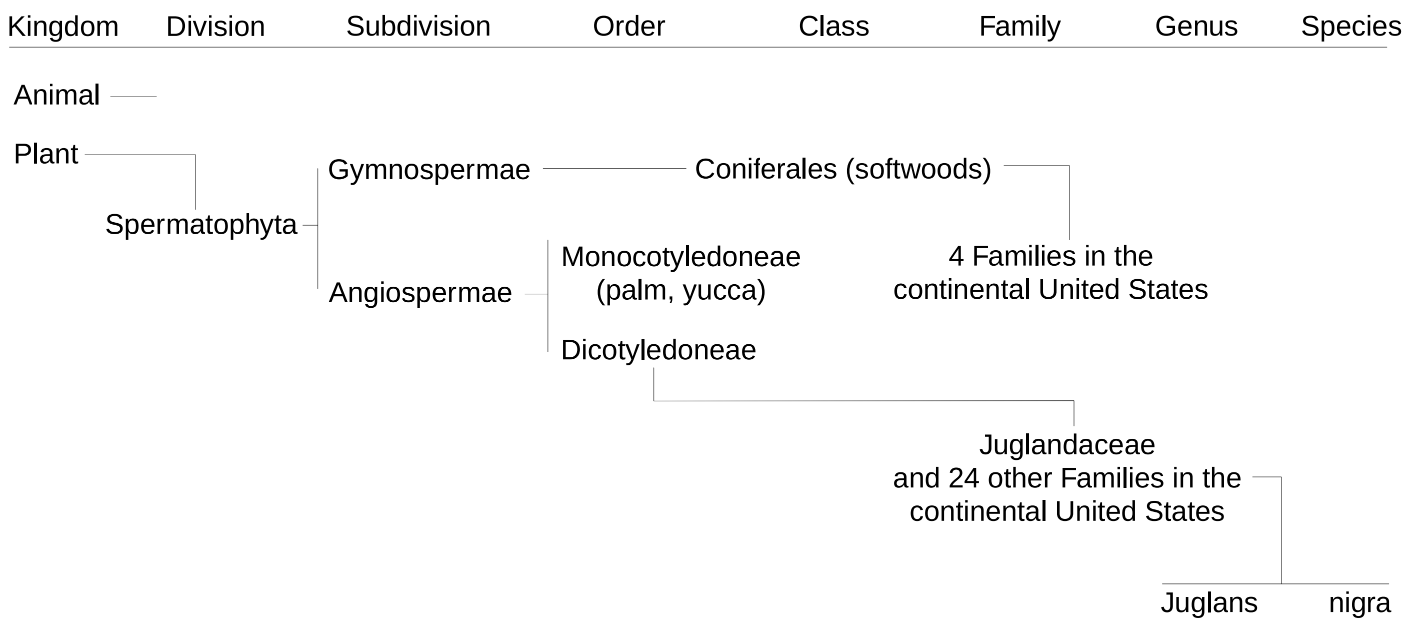


Figure 1. Classification of trees. Example of eastern black walnut

ARTICLE
OER

79

The Five Major Types of Biomes

A biome is a large community of vegetation and wildlife adapted to a specific climate.

GRADES
5 - 8

SUBJECTS
Biology, Ecology

1/2

PHOTOGRAPH

Saguaro Cacti

Large Saguaro cacti (Carnegiea gigantea) pop up in various spots around a barren desert in Arizona, United States.

PHOTOGRAPH BY THOMAS ROCHE

BACKGROUND INFO VOCABULARY

Learning materials

INSTRUCTIONAL LINKS

- View this resource on OER Commons
- View this resource as a Google Doc

A biome is a large area characterized by its vegetation, soil, climate, and wildlife. There are five major types of biomes: aquatic, grassland, forest, desert, and tundra, though some of these biomes can be further divided into more specific categories, such as freshwater, marine, savanna, tropical rainforest, temperate rainforest, and taiga.

Aquatic biomes include both freshwater and marine biomes. Freshwater biomes are bodies of water surrounded by land—such as ponds, rivers, and lakes—that have a salt content of less than one percent. Marine biomes cover close to three-quarters of Earth's surface. Marine biomes include the ocean, coral reefs, and estuaries.

Grasslands are open regions that are dominated by grass and have a warm, dry climate. There are two types of grasslands: tropical grasslands (sometimes called savannas) and temperate grasslands. Savannas are found closer to the equator and can have a few scattered trees. They cover almost half of the continent of Africa, as well as areas of Australia, India, and South America. Temperate grasslands are found further away from the equator, in South Africa, Hungary, Argentina, Uruguay, North America, and Russia. They do not have any trees or shrubs, and receive less precipitation than savannas. Prairies and steppes are two types of temperate grasslands; prairies are characterized as having taller grasses, while steppes have shorter grasses.

Forests are dominated by trees, and cover about one-third of the Earth. Forests contain much of the world's terrestrial biodiversity, including insects, birds, and mammals. The three major forest biomes are temperate forests, tropical forests, and boreal forests (also known as the taiga). These forest types occur at different latitudes, and therefore experience different climatic conditions. Tropical forests are warm, humid, and found close to the equator. Temperate forests are found at higher latitudes and experience all four seasons. Boreal forests are found at even higher latitudes, and have the coldest and driest climate, where precipitation occurs primarily in the form of snow.

Deserts are dry areas where rainfall is less than 50 centimeters (20 inches) per year. They cover around 20 percent of Earth's surface. Deserts can be either cold or hot, although most of them are found in subtropical areas. Because of their extreme conditions, there is not as much biodiversity found in deserts as in other biomes. Any vegetation and wildlife living in a desert must have special adaptations for surviving in a dry environment. Desert wildlife consists primarily of reptiles and small mammals. Deserts can fall into four categories according to their geographic location or climatic conditions: hot and dry, semiarid, coastal, and cold.

A tundra has extremely inhospitable conditions, with the lowest measured temperatures of any of the five major biomes with average yearly temperatures ranging from -34 to 12 degrees Celsius (-29 to 54 degrees Fahrenheit). They also have a low amount of precipitation, just 15–25 centimeters (six to ten inches) per year, as well as poor quality soil nutrients and short summers. There are two types of tundra: arctic and alpine. The tundra does not have much biodiversity and vegetation is simple, including shrubs, grasses, mosses, and lichens. This is partly due to a frozen layer under the soil surface, called permafrost. The arctic tundra is found north of boreal forests and the alpine tundra is found on mountains where the altitude is too high for trees to survive. Any wildlife inhabiting the tundra must be adapted to its extreme conditions to survive.

Credits

Tree Health Assessment and Risk Management

Figure 1. Whether a conifer (left) or a hardwood (right), most trees grow best with a single, dominant stem for the tree trunk. A tree canopy should be full and green during the growing season, unless it is autumn and showing fall color.

Tree Health Assessment

Trees are abundant across Mississippi. The combination of fertile soil, plenty of rain, and ample sunshine ensure that trees are the predominant vegetation. Forests and the forest industry contribute up to $1.5 billion to the state economy every year. However, trees contribute more than dollars and cents; they provide our cities, towns, and neighborhoods with numerous environmental benefits. Trees give us shade in the summer, reduce noise and pollution from traffic, increase property values, and enhance our quality of life.

What makes a tree healthy? Whether the tree is a conifer or hardwood, there should be a single, dominant main stem (Figure 1). Some tree species, like the river birch, have a multi-stemmed growth formation (Figure 2). Preferably, the tree trunk should be straight and the bark intact, without bulges or cracks. On a healthy tree, the root collar flares at the trunk base as the structural roots radiate away from the main stem supporting the tree in the soil (Figure 3). As trees age, the structural roots enlarge, forming the root plate.

During the growing season, a healthy tree should have a full canopy of leaves. Furthermore, the leaves should be green and expanded without stunting or wrinkling. As the tree grows, branches should spread from the main stem without crossing one another.

Many people believe if a tree is not dead, then it's okay. Sadly, this is not necessarily true. Living trees require regular care and maintenance to remain healthy. Trees are rooted in place and cannot visit the doctor when they are sick. Trees cannot "speak" to us about what is bothering them. So, diagnosing tree health problems requires that we become detectives. We must observe what is happening to the tree and determine if it is a normal part of the tree's life cycle or detrimental to the tree's overall health.

Figure 2. River birch may grow with a single stem or have a multi-stemmed form as shown.

Figure 3. On a healthy tree, the root collar flares as the structural roots radiate away from the main stem supporting the tree in the soil. The structural roots at the base of a tree form its root plate.

Figure 4. The shear crack (left) goes entirely through the tree. This tree failed several months later. The inrolled crack (right) is along the cavity edge.

Tree Defects

With this in mind, let's put on our detective's cap and begin to assess tree health. Start by walking completely around the tree while examining the roots, trunk, and branches. Look for abnormalities or defects. More than 80 percent of trees that fail during storms have defects. Learning to identify tree defects is paramount to proper tree maintenance and risk management. Tree defects include cracks, decayed wood, weak branch unions, cankers, root problems, poor tree architecture, and dead trees, tops, or branches.

Cracks

Cracks are more than just splits in the bark. They typically go through the bark and into the wood of the tree. Cracks are signs that the load is exceeding the capacity of the wood to support the tree or branch. Shear cracks are vertical with the grain of the wood (Figure 4, left). Ribbed cracks occur as the tree tries to grow over a vertical crack. Tree movement or cold temperatures re-open the crack, so the tree grows a mound along the crack. Inrolled cracks occur as wood grows over a cavity (Figure 4, right). However, included bark prevents the wound from healing completely. Instead, the crack is perpetuated and enlarges. Horizontal cracks occuring across the grain indicates that wood fibers are pulling apart.

Trees with cracks have a moderate risk for failure. If the crack is splitting, or if there are multiple cracks or decay, then the tree has a high risk for failure. Any large branch (> 4 in diameter) with a crack has a high risk for failure.

Decayed Wood

Decayed wood is the result of a long-term interaction of fungi with the wood of the tree. Decay begins with a wound in the tree from injury, insects, or disease. The decomposition process progresses through several stages from stain, to rot, to a cavity. Signs of decomposition may be revealed in different ways. Loose bark is an indication that the wood underneath is dead. Fruiting bodies on the tree (Figure 5) reveal advanced decay that is active within the tree. When present, mushrooms or conks enable identification of the decay or disease fungus. Meanwhile, an open crack or cavity might reveal decayed wood or a completely hollow tree (Figure 6).

Decay within trees seriously weakens their structural integrity. Depending on the decay fungi, wood around a hollow or cavity may grow thicker, creating a bulge or swelling of the trunk (Figure 6, right). Generally, a hollow trunk needs 1/3 its thickness in structurally sound wood to support itself. If there is an opening into the tree (a cavity), it

Figure 5. Fungal fruiting bodies on trees indicate the presence of disease or decay fungi within the tree. In this case the fungus is an oyster mushroom, *Pleurotus* spp. Photo by S. Tucker

Figure 6. Cavities are openings into a tree. They might reveal the decaying wood of heartrot (left), or that decay has progressed to completely hollow the tree (right). Note the bulges in the trunk along the cavity in response to the interior decay.

should occupy 1/3 or less of the tree's diameter. Less sound wood than stated means the tree is a high risk for failure.

Evidence of decay across 25 to 40 percent of the trunk or root collar circumference has a moderate risk for failure. Greater than 40 percent decay across the circumference has a high risk for failure. A cavity extending greater than 30 percent of the circumference of the trunk has a high risk for failure. Also, any large branch (> 4 in diameter) with decay has a high risk for failure.

Weak Branch Unions

Different tree species have different wood properties. Several common types of trees in Mississippi are more prone to branch failure due to weak joints or brittle wood. Such trees include ashes, basswood, birches, black locust, cottonwood, elms, maples, pears, pines, or sugarberry. These trees should be planted away from driveways, roads, and structures. Mississippi State University Extension Service offers publications for reference when planting trees, listed in the Additional Reading section at the end of this publication.

Figure 7. This pine has co-dominant stems which have grown together (left) with included bark squeezed in between. Right: Epicormic branches have sprouted from the outer wood in response to a pruning cut.

Weak branch unions can also occur when branches or stems have bark between them. For instance, with co-dominant stems, two or more stems of comparable size occur in the tree, resulting in a multi-stemmed tree. As co-dominant stems grow, they may squeeze each other (Figure 7). This squeezed union is weak due to the included bark. Moreover, as the stems move in wind they rub and may create a wound, leading to decay which further weakens the tree.

Epicormic branches grow from buds beneath the bark. These buds are released to grow when the tree is stressed. Since the wood of the epicormic branch originates in the outer growth rings rather than from the center of the branch, these branch unions are weaker (Figure 7). Epicormic branches grow quickly and may sometimes fail under their own weight.

Cankers

Cankers may be caused by injury, insects, or disease in branches or the trunk. Once started, canker disease infects wood in each new growth ring, deforming and weakening the branch or stem as it spreads. Consequently, sound wood cannot cover the wound. This is especially troublesome when the canker occurs on the main stem (Figure 8).

Cankers can make the trunk or branch more prone to failure in wind at the infection site. Trees with a canker plus associated decay across 25 to 40 percent of the tree's circumference have a moderate risk for failure. Cankers covering greater than 40 percent of the tree's circumference indicate a high risk for failure.

Figure 8. Canker diseases occur on many types of trees such as pine (left) or hardwood (right). These deformities enlarge with the tree as it grows, making the trunk more prone to failure.

Root Problems

Where the tree trunk meets the roots is known as the root collar. Usually, there is a flare at the base of the trunk where the structural roots radiate away from the tree (Figure 3). Occasionally, a tree might not show a flare at its root collar. Usually, this is observed on trees which were planted too deeply (Figure 9, left). The tree might survive and grow, but there is a greater possibility for rot to develop in its roots. Applying too much mulch can have the same effect (Figure 9, right).

Figure 9. Sometimes the root flare is not seen, particularly on trees that were planted too deeply (left). Applying too much mulch (right) can have the same effect as planting too deep.

Figure 10. Crossing or circling roots indicate poor root architecture. Crossing or circling roots may restrict other roots as they grow and impair water uptake.

Crossing or circling roots is another common root problem. Tree roots grow in the direction they are pointing. Roots that circle the tree or cross roots will constrict other roots (Figure 10). Such roots may eventually impair water uptake and kill the tree. Girdling roots that constrict more than 40 percent of the root collar circumference present a high risk for failure.

Some root problems are revealed by the health of the tree canopy. A healthy tree maintains its leafy canopy with healthy roots. If the tree suffers root loss from disease, injury, or soil compaction, there is a consequent reduction in leaf area as branches die back. This is known as canopy decline (Figure 11). Some tree species are more sensitive to root damage or soil compaction. These species include American hornbeam, basswood, black cherry, black oak, black walnut, Eastern hophornbeam, pin oak, and white oak. Moderate crown dieback (about 30 percent in pine or 50 percent in hardwoods) indicates a moderate risk for failure. Without intervention, canopy decline continues until the tree dies.

Just as with tree trunks and branches, the presence of mushrooms or conks on the root collar indicates decay or disease (Figure 12). Fungal fruiting bodies, when present, usually indicate advanced decay or infection in the root system. Decay across 25 to 40 percent of the root collar circumference indicates a moderate risk of failure.

The structural roots forming the root plate can be damaged by mowers or string trimmers (Figure 13, left). The greatest stress on roots supporting a tree is above the soil line, which is where mowers or trimmers cause damage. It is best to mulch around trees (Figure 13, right) to keep traffic and equipment away from the root plate.

Finally, root damage from construction (cutting roots and/or soil compaction) causes defect. The critical root area around a tree is determined by a circle having a radius of 1.5 ft for every inch of diameter measured at breast height (4.5 ft above the ground). This area is usually beyond the drip line of the tree canopy. When construction projects are planned, the critical root area for protected trees should be marked with temporary fencing. No traffic of any sort should go into the critical root zone, and construction contracts should specify this. Root damage beyond 40 percent of the critical root area presents a high risk for tree failure.

Poor Tree Architecture

Although a tree trunk should grow plumb with the earth, such is not always the case. A leaning tree (15 to 40 degrees from plumb) is more prone to failure (Figure 14, left). There are other signs of failure in a leaning tree. A horizontal crack may form opposite the tree lean. Bulges in the bark and wood may form in the side of the lean as the tree buckles. In addition, a leaning tree may exhibit soil failure, whereby the root-ball starts to rise out of the ground, creating a mound of soil opposite the lean (Figure 14, right). Trees with excessive lean (> 40 degrees from plumb), or a lean with other defects such as cracks, decay, or soil mounding have a high risk for failure.

Figure 11. Severe crown dieback or damage indicates root loss and increases the risk for failure.

Figure 12. The appearance of mushrooms at the root collar indicates root rot. Pictured is the decay fungus *Inonotus dryadeus* on a willow oak.

Figure 13. Structural roots of the root plate often rise above the ground in mature trees (left), where they may be damaged by mowers or string trimmers.Making a mulched bed around trees protects the root plate from excessive traffic and equipment (right).

Figure 14. Moderate lean (15 to 40 degrees from plumb) can increase the risk of failure for a tree (left). The root ball of a failing tree will start to rise out of the soil opposite the lean (right) for high risk of failure.

An unbalanced crown is another example of poor tree architecture. Often, storm-damaged trees loose significant portions of their canopy (Figure 15). This substantial loss of canopy decreases the ability of the tree to grow. Such loss of canopy can put a tree into decline. Also, lopsided trees are at a continued risk of failure, especially when their remaining canopy is caught in strong winds.

Dead Trees, Tops, and Branches

As trees mature, it is natural for branches to die as they become shaded. Decay fungi begin working once a tree has died, eventually destroying the structural integrity of the wood. The decay process works quickly in warm, humid climates. Therefore, dead wood is a high risk for hazard (Figure 16). Furthermore, cracked or hanging branches could fall at any time. These situations require immediate attention to mitigate risk. Regular maintenance is required to keep wooded areas safe by removing dead trees and branches.

Figure 15. Poor tree architecture can be created by storm damage and/or improper maintenance over time. Given its multiple defects and location next to a park trail, this tree should be removed.

Figure 16. Dead wood decays quickly in warm, humid climates. Dead trees, tops, and branches (bottom) should be removed regularly to keep our forested landscapes safe.

Risk Management

Hazardous Trees

Not every tree with defects is hazardous. When determining the risk of hazard, three things must be evaluated:

1. Conduct a tree health assessment to find any defect(s). This evaluation is used to assess the risk for failure.
2. Consider the size and weight of the tree or limb. Progressively higher risk is associated with larger branches or trees.
3. Note the proximity of the tree to any potential target. Potential targets include people and/or property that might be struck if the tree or branch fell.

Tree defect(s), weight of affected part of the tree, and its likelihood to strike a target are the primary factors used to determine the risk of hazard.

Risk Assessment System

We can rank the overall risk of a potentially hazardous tree using the three components described. This is done by evaluating each hazard component of the tree and then combining those individual ratings (see Risk Management System section). Tables 1–3 summarize the risk assessment for each hazard component using a 4-point scale. Table 1 provides a rating of risk for tree or limb failure. Each risk category includes a description of tree defects and their degree of development. Table 2 gives a risk rating based on the size and weight of a tree part. Small diameter limbs (< 4 inches in diameter) may weigh several hundred pounds, whereas large trees might weigh several tons. Table 3 furnishes a risk rating for the likelihood of a tree, limb or branch hitting a target. The higher the pedestrian use, vehicular traffic, or proximity of structures around the tree, the greater the risk for hitting a target.

Table 1. Likelihood of tree or limb failure.

Risk Rating for Tree/Limb Failure	Description
1: Low	A few, minor defects present: • Small wounds or cavities with sufficient sound wood • A few, small defects (e.g., limited stem decay affecting < 25% of tree circumference, girdling root tree lean < 15 degrees from plumb) • Some crown dieback (< 30% of canopy)
2: Moderate	Moderate defects present: • Decay in stem present but within safety limits for sound wood (shell of sound wood ≥ 1/3-thickness of diameter for a hollow; shell of sound wood ≥ 2/3-thickness of diameter for a cavity) • Crack without decay • Cavity or decay affecting 25-40% of tree circumference • Moderate crown dieback or damage (about 30% for pine; about 50% for hardwood) • Co-dominant stem with included bark • Stem girdling roots (< 40% root collar circumference) • Root damage (< 40% critical root area) • Tree lean 15-40 degrees from plumb
3: High	Multiple or significant defects present: • Decay in stem exceeding safety limits for sound wood • Cavity or decay affecting > 40% tree circumference • Severe crown dieback or damage (> 30% for pine; > 50% for hardwood) • Co-dominant stems and/or weak branch unions with cracks or decay • Girdling roots > 40% tree circumference • Root damage > 40% critical root area • Tree lean 15-40 degrees from plumb with root breakage, or soil mounding, or decay • Standing dead tree or dead limbs without other defects
4: Extreme	Multiple or significant defects present: • Decay in stem exceeding safety limits for sound wood and with a crack • Crack splitting stem or branch in two • Tree lean > 40 degrees from plumb with a crack or extensive decay, root breakage, or soil mounding • Dead tree with decay or cracks • Dead, broken limbs (hangers) or with cracks • Visual obstruction of traffic signs or lights • Physical obstruction to pedestrian or vehicular traffic

Table 2. Risk from size of defective part.

Risk Rating for Size	Description
1: Low	Small: Stem or branch < 4 inches in diameter (< 500 lbs)
2: Moderate	Medium: Stem or branch 4 – 16 inches diameter (500 lbs – 2 tons)
3: High	Large: Stem or branch 16 – 30 inches diameter (2 – 10 tons)
4: Extreme	Huge: Stem or branch > 30 inches diameter (> 10 tons)

Table 3. Likelihood of hitting a target.

Risk Rating for Hitting a Target	Description
1: Low	Infrequent: • Natural areas such as woods or riparian zones with limited public use • Low use areas including roads or park trails; Parking lots adjacent to low use areas • Industrial sites with limited use of trees in landscaping
2: Moderate	Intermediate: • Low use school playgrounds, parks, picnic areas • Parking lots adjacent to moderate use areas • Secondary roads, neighborhoods, park trails • Dispersed campgrounds
3: High	Frequent: • Emergency access routes, medical emergency facilities • Handicap access areas • High use school playgrounds, parks, picnic areas, bus stops, streets • Parking lots adjacent to high use areas • Interpretive signs or kiosks, scenic vistas, visitor centers, campsites • Homeowner yards • Proximity of tree or limb to structures (homes, garages) • Proximity of tree or limb to busy pedestrian or vehicular traffic
4: Extreme	Additional risk factors beyond High: • Species prone to particular defects • Likelihood of tree or limb failure before next inspection

Table 4. Combining risk rating from each hazard component for overall risk ranking.

Overall Risk Ranking	= Risk for Failure + Risk for Size + Risk for Hitting Target
Low	< 4
Moderate	4 – 6
High	7 – 9
Extreme	> 9

Finally, Table 4 shows how to combine the risk hazards into an overall risk ranking. Although subjective, the risk ranking does provide a means toward prioritizing attention for intervention. Since they are subjective, risk ratings can be adjusted to reflect a higher ranking to prompt intervention.

Corrective Actions

Hazardous tree situations can be remediated by addressing and/or changing any one of the three components mentioned. Solutions will vary with the circumstances of each situation. In all cases, consideration for personal safety takes precedence.

Sometimes, removing the target might be an option. For instance, a hazard tree in an open park can be maintained by putting a fence around the tree to keep people away. If the hazard is from dead limbs, temporary fencing will protect people until pruning is done to remove the dead wood.

Removing the hazard is another option. Some defects can be mitigated to lessen the potential impact. Cracks or co-dominant stems could be braced with a bolt to reduce the risk of tree failure (Figure 17). Similarly, a leaning tree could be cabled to mitigate its risk of failure. Measures like bracing and cabling require periodic inspections by qualified arborists to maintain safety.

Pruning is an option to remove dead branches, or balance the canopy of a tree. Yet, not all tree defects can be mitigated easily. There will be many situations where removing the tree is the best option despite its higher cost.

Preventive Actions

Many hazard tree situations can be avoided by having a proactive individual or urban forestry program in place. This starts with planting the right tree in the right place. Site conditions (soil, moisture, sunlight, available space) should be matched with trees that prefer those specific conditions (Figure 18). Trees should be planted to the same depth as their root mass, with the root collar at ground level. This allows the root flare to be exposed to air and helps the tree avoid root disease.

Maintaining trees with a regular pruning schedule is ideal, permitting them to grow with fewer defects. A co-dominant stem can be easily eliminated while the tree is young. Periodic pruning will also prevent branches from crossing, which may cause wounding and lead to decay. Furthermore, pruning small branches permits faster healing since the wounds are smaller.

Figure 17. Bracing bolts stabilize co-dominant stems.

Figure 18. Planting a tall-growing tree such as this pine was not appropriate in a powerline right-of-way.

Fusiform Rust in Arkansas

Kyle Cunningham
Associate Professor
of Forestry

Fusiform rust, caused by the fungus *Cronartium quercuum* f. sp. *fusiforme*, is the most destructive disease of loblolly and slash pine in the southeastern United States. It causes the greatest economic losses in pine plantations but also can cause significant losses in seed orchards and natural pine stands. Although severe disease may occur in Arkansas at times, fusiform rust is a more serious problem south and east of the state, from eastern North Carolina to central Louisiana (Figure 1). Loblolly pine is the only species native to Arkansas which is susceptible to fusiform rust.

The disease is characterized by spindle-shaped galls on branches and stems of pines. In some cases, the galls may be round or irregular. Fusiform rust galls frequently completely girdle and kill trees less than five years old (Figure 2). Older trees can survive infection indefinitely but will be structurally weakened (Figure 3). The structural damage reduces the quality and value of the stem and increases the chances that the stem will break during wind or ice storms.

Figure 2. Fusiform rust has girdled this young pine stem. It will not survive.

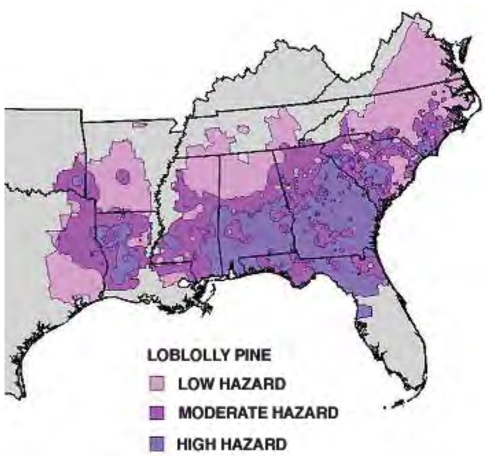


Figure 1. Range and frequency of fusiform rust infections in the southeastern U.S. Infection rates for the hazard classes are: low = 0 to 9 percent, moderate = 10 to 30 percent and high = 31 to 100 percent.

Figure 3. This fusiform-infected stem will survive the infection but is more susceptible to breakage.

Biology and Disease Cycle of *C. quercuum* f. sp. *fusiforme*

Fusiform rust requires both pine and oak for completion of its life cycle (Figure 4). In the fall and winter, galls exude droplets of liquid called pycnia which contain pycniospores (Figure 5). Four months to several years later, during the spring, the galls produce yellow to white aecia at the former locations of the pycnia. The aecia are filled with yellow to orange aeciospores, which are wind-disseminated (Figure 6). The aeciospores infect the immature leaves of red oaks but cause no economic damage to oaks. On oaks, the fungus first produces small yellow structures called uredinia within two weeks of infection (Figure 7). The uredinia produce and release urediniospores which reinfect the oak upon which they developed. The reinfected sites develop hairlike or whiplike structures called telia (Figure 8). Telia produce teliospores which germinate and produce four basidiospores each. The basidiospores are released at night and are carried by wind to the succulent young needles and cones of susceptible pines. The fungal infection eventually spreads from the needles and cones into the branches or stem of the tree where it lives for years and produces the characteristic galls, completing the complicated life cycle of fusiform rust. It takes two years or more to complete the life cycle.

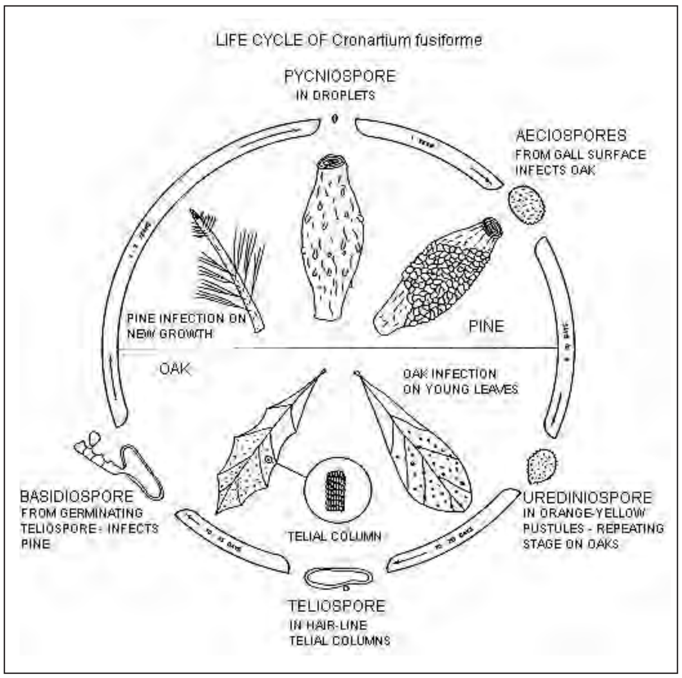


Figure 4. Life cycle of fusiform rust.

Figure 5. Pycnia of fusiform rust.

Figure 6. Aecia releasing aeciospores.

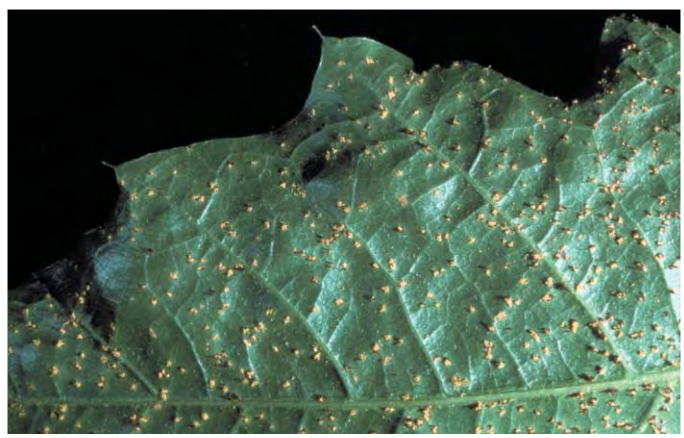


Figure 7. Uredinia on the underside of an oak leaf.

Figure 8. Telia on the underside of an oak leaf.

Identification

One of the best control techniques for any disease is early detection. To this end, a brief discussion of fusiform rust identification is in order. Galls are one of the most recognizable and most easily identified indicators of fusiform rust. During spring the yellowish aecia will make most of the galls easy to recognize. At other times of the year, galls will have bark that is similar in texture and color to normal pine bark. In most cases, gall shape should be readily identifiable any time of year (Figures 2 and 3).

Stages of fusiform rust on oak are also easy to identify but will be much more difficult to locate. Uredinia and telia are quite small and occur on the bottom surface of oak leaves. A hand lens will be helpful. Any small yellow spots or structures on the bottom surface of a red oak leaf should be examined closely with a hand lens. Uredinia will look like clumps of yellow particles on the leaf surface (Figure 9). Telia will look like dark brown hairs on the leaf surface (Figure 10). An infected leaf may have only a few or a few hundred uredinia and telia.

Figure 9. Close-up of uredinia on an oak leaf.

Figure 10. Close-up of telia on an oak leaf.

Occurrence in Arkansas

USDA Forest Service surveys in 2005 showed that less than 11 percent of pine stands in Arkansas had fusiform rust infection rates greater than 10 percent of trees. This is significantly less than the south-wide average of 28 percent of stands and far less than the near 50 percent of stands in Georgia. Several factors are believed to influence fusiform rust infection rates. Arkansas' less humid climate, compared to states south and east of us, may help reduce infection rates. Also, western loblolly pines are more resistant to fusiform rust infection than eastern loblolly pines for reasons not yet fully understood. Forest conditions such as stand density and nutritional status also influence infection rates. Historically, very little data on fusiform rust infection rates has been collected; therefore, long-term trends in infection rates are poorly understood.

Control Measures

Seedlings – Essentially all modern loblolly pine seedling varieties are screened for resistance to fusiform rust. When you order seedlings, make sure to state that you want rust-resistant seedlings. Seedlings should be inspected for fusiform rust prior to planting. Should infected seedlings be found, return them to the nursery for replacement. **Do not plant infected trees.**

Forest Trees – During the first five years, plantations should be monitored for outbreaks of fusiform rust. Heavily infected stands should be replanted. On a forest-wide scale, pruning and chemical control are not commercially feasible. Lightly infected stands should be left alone until the first thinning. At that time, infected trees should be marked and removed. Wounds may make pines more susceptible to fusiform rust infection; therefore, take care to avoid skinning trees when the stand is thinned. Because the fusiform rust life cycle alternates between pine hosts and oak hosts, some have advocated stand protection through using herbicides or prescribed fire to control oaks within the stand. Since fusiform rust spores can be carried up to a mile by wind, eliminating oaks within the stand may not actually reduce the risk of infection in small stands.

Lawn Trees – Loblolly pines in lawns also are susceptible to fusiform rust. To minimize the risk of infection, do not fertilize the soil around pines until they are at least 10 years old. Fertilizing a tree increases the amount of new growth, which creates more sites for fusiform rust infection. Trees more than 10 years old are still susceptible to fusiform rust but are much less likely to be killed by the fungus. In some cases, infections in ornamental pines can be treated. Small galls can be cut out of the trunk; however, great care must be exercised to remove **all** of the infected tissue without weakening the tree excessively. Large galls on the trunk can rarely be successfully removed. Removing enough tissue to completely remove a large gall will render a tree dangerously weak and will increase the likelihood that the tree will break during a storm. This may result in property damage or personal injury. Such trees should be removed. If galls are on branches and are more than a foot from the trunk, pruning the infected branches offers the best control method (Figure 11). If galls on branches are within a foot of the trunk, the trunk probably is already infected as well. For more information on pruning branches, refer to Cooperative Extension Service publication FSA5011, *Ten Easy Ways to Kill a Tree (And How to Avoid Them)*.

Figure 11. Branches with fusiform rust infections more than a foot from the trunk can be pruned.

Homeowners in south Arkansas, where the risk from fusiform rust is greater, should consider planting loblolly pine from families which are less susceptible. Planting a resistant species such as shortleaf pine might be an even better alternative.

Conclusions

Fusiform rust has not been a major problem in Arkansas during the last 20 to 30 years; however, when an infection occurs in a forest or ornamental tree, the result can deal a financial blow to a small private landowner or homeowner. Vigilance and a few inexpensive steps can help landowners significantly reduce the risk of loss to fusiform rust.

References

Anderson, Robert L., and Paul A. Mistretta, 1982. *Management Strategies for Reducing Losses Caused by Fusiform Rust, Annosus Root Rot, and Littleleaf Disease.* USDA Forest Service, Cooperative State Research Service. Agriculture Handbook No. 597.

Anonymous. 2004. *Forest Insect and Disease Conditions in the United States 2003*. USDA Forest Service. Forest Health Protection annual report for 2003.

Phelps, W. R., and F. L. Czabator, 1978. *Fusiform Rust of Southern Pines.* USDA Forest Service. Forest Insect and Disease Leaflet 26.

Powers, H., and E. G. Kuhlman, 1997. Fusiform Rust. In: *Compendium of Conifer Diseases.* Everett M. Hansen and Katherine J. Lewis, editors. The American Phytopathological Society. pp. 27-29.

Sinclair, Wayne A., Howard H. Lyon and Warren T. Johnson, 1987. *Diseases of Trees and Shrubs.* Cornell University Press. Ithaca, NY. p. 270.

Starkey, Dale A., Robert L. Anderson, Carol H.Young, Noel D. Cost, John S. Vissage, Dennis M. May and Edwin K. Youckey, 1997. *Monitoring Incidence of Fusiform Rust in the South and Change Over Time.* USDA Forest Service. Southern Region, Forest Health Protection. Protection Report R8-PR-30.

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Photo Credits: Figure 1. U.S. Forest Service Web page, http://www.fs.fed.us/r8/foresthealth/hosf/fusrust.htm. Accessed May 8, 2013. Figure 2, 5, 6, 7, 8, 9, 10 and 11, Robert L. Anderson, USDA Forest Service, Bugwood.org. Figure 3. Clemson University, USDA Cooperative Extension Slide Series, Bugwood.org. Figure 4 adapted from Phelps and Czabator 1978.

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NCF-Envirothon 2026 Mississippi

Forestry Study Resources

Key Topic #2: Forest Ecology

6. Describe the major types of forests in Mississippi
7. Differentiate between hardwood, softwood, and mixed stands.
8. Explain how forested ecosystems impact the water cycle and benefit water quality, and the role of forest and other plant communities on watershed health.
9. Define an ecological niche and describe how different organisms in forest ecosystems fulfill these roles.
10. Define resilience and describe what it means for ecosystems and plant species.

Resource Title	Source	Located on Page
Forestry Facts	*Martin, J., & Gower, T. (1996). Forest succession. University of Wisconsin. https://forestandwildlifeecology.wisc.edu/wp-content/uploads/sites/111/2017/07/78.pdf*	30
What is Heartwood in Trees?	*Weikert, S. (2024). What is heartwood in trees? https://extension.psu.edu/what-is-heartwood-in-trees*	34
Vertical Forest Stratification	*Pennsylvania Woodlands. (2015). Vertical forest stratification. https://www.ltsd.k12.pa.us/wp-content/uploads/2015/08/Vertical-Forest-Stratification.pdf*	38
Ozone effects on plants in natural ecosystems	*Grulke, N. E., Heath, R. L (2019). Ozone effects on plants in natural ecosystems. Plant Biology © 2019 German Society for Plant Sciences and the Royal Botanical Society of the Netherlands.*	40
Longleaf Pine Trough Time	*Mississippi State University Extension. (2000). https://extension.msstate.edu/sites/default/files/document/2025-11/P4134_web.pdf*	43
Mississippi Historic Forest Boundaries	*Mississippi Forestry Commission. (2020). Mississippi's Forest Action Plan 2020 Update. https://www.mfc.ms.gov/wp-content/uploads/2021/01/Mississippi-Forest-Action-Plan-January-2021-compressed.pdf*	54

FORESTRY FACTS

UW Extension

College of Agricultural & Life Sciences
University of Wisconsin-Madison

Department of Forest Ecology and Management • School of Natural Resources

No. 78 **November, 1996**

Forest Succession

Jeff Martin and Tom Gower

Succession is the natural replacement of plant or animal species, or species associations, in an area over time. When we discuss forest succession, we are usually talking about replacement of tree species or tree associations.

Each stage of succession creates the conditions for the next stage. Temporary plant communities are replaced by more stable communities until a sort of equilibrium is reached between the plants and the environment. The following sequence is usually observed if sufficient time passes and no disturbance occurs:

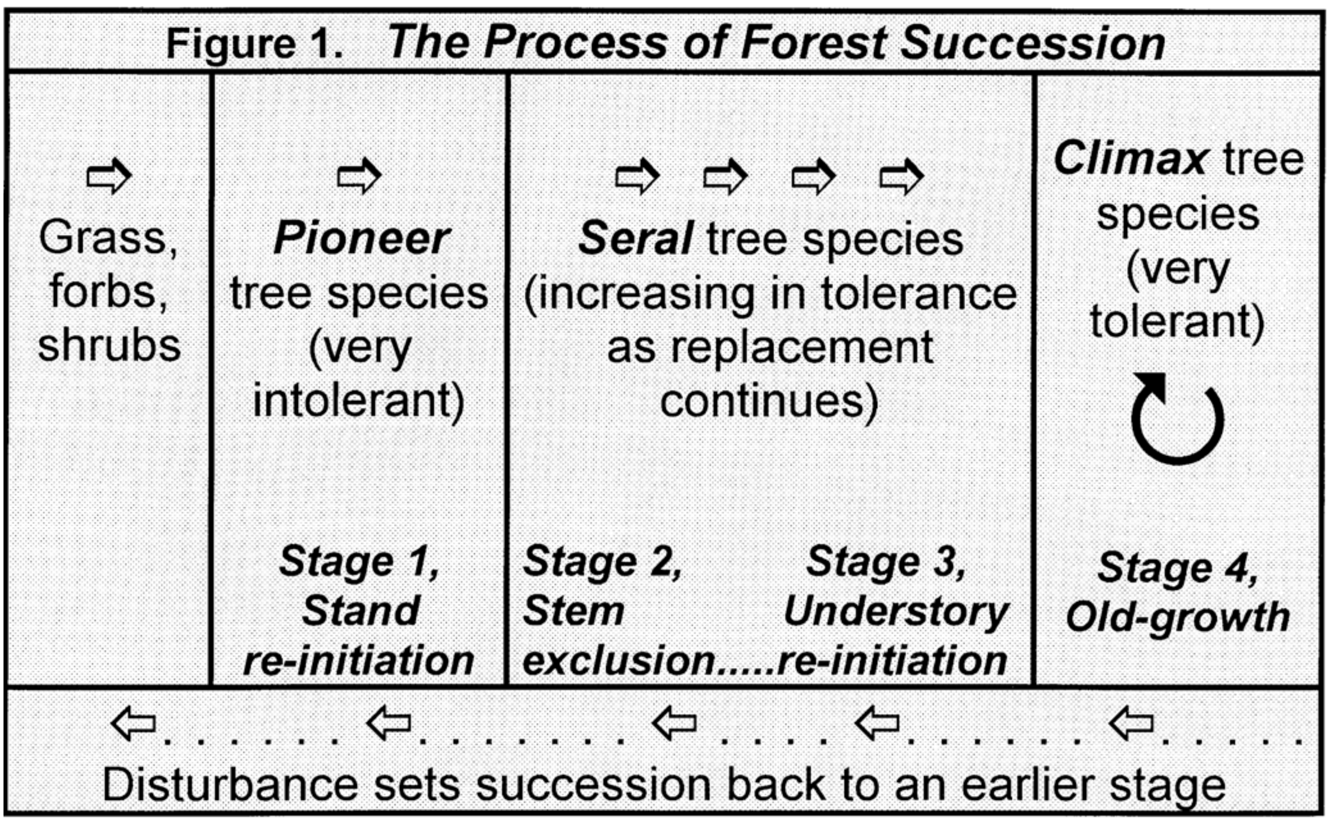
Plant Community	Description
Grass-forb:	Forbs, grasses and shrubs dominate the site. Seedlings may be present.
Shrub-seedling:	Trees tend to share and then begin to dominate the site. The intolerant species (see Forestry Fact No. 79, Tolerance of Tree Species) grow rapidly and dominate over tolerant species.
Sapling-pole:	Trees eventually overtop and out-compete the forbs and shrubs. The intolerant trees continue rapid height growth while the tolerant trees occupy their respective niche.
Young:	Growth is still rapid. Tree-to-tree competition may be severe resulting in competition caused mortality. Any intolerant individuals that drop behind may die and their growing space may be occupied by tolerant trees.
Mature:	Competition caused mortality continues. Both intolerant and tolerant trees may share the main canopy. In mixed conifer stands there may be a distinct layering of intolerants and tolerants.
Climax:	A relatively stable plant community which has a dominant plant population suited to the environment. Tolerant species dominate the site and the climax species will reproduce successfully under their own shade. These species will maintain the community under the current climatic conditions. Intolerant trees cannot reproduce.

Disturbance

The rate of natural succession is affected whenever a disturbance such as fire, a windstorm, pests or management activities occurs on the site. The more severe the disturbance, or the more often disturbances occur, the slower will be the natural process of succession.

Following a major disturbance, **pioneer species**, such as aspen or jack pine, will become established in open areas under full sunlight. Eventually, in the absence of further disturbance, these pioneer species will be replaced by **seral species** that will occupy the site through a series of successional stages, leading ultimately to a plant community comprised of **climax** species.

Forest successional stages are closely tied to the tolerance of various tree species (see Forestry Fact No. 79, Tolerance of Tree Species, for more information). For example, very tolerant species such as sugar maple, beech and hemlock are climax species on many sites in Wisconsin where they are capable of normal growth. However, sugar maple does not typically grow on dry, sandy soils



and therefore cannot replace jack or red pine on such sites.

Other Stand Changes

In addition to the well-studied changes in species composition during succession, there are other changes, in the structure and function of the stand, that are also taking place. Although the changes are subtle and continuous, ecologists have developed relatively simple stand development classification systems to classify forests according to their stage of succession. Figure 1 illustrates the four basic stages of stand development recognized for even-aged forests, and shows how they relate to the typical forest plant communities.

Stand re-initiation denotes the beginning of succession. Woody and foliage biomass steadily increase during this stage. Another important characteristic of this stage is that resources that influence tree growth (e.g. light, water and nutrients) are abundant relative to the other stages of stand development.

The second stage, **stem exclusion**, marks the onset of intense inter- and intraspecies competition for limiting resources, resulting in mortality or self-thinning. Foliage mass reaches a maximum near the onset of this second stage - this is noteworthy because foliage is the tissue that carries on photosynthesis and is the primary tissue regulating the growth of the forests. Foliage mass remains relatively stable or decreases by 10-30% in the older stages of stand development and this decline may be responsible for decreased forest growth in older forests (see the next section).

The third stage, **understory re-initiation**, is characterized by renewed growth of the understory in response to gaps in the canopy caused by tree mortality.

The fourth stage is referred to as **old-growth**; managed forests seldom reach this stage because the growth of these forests is often 10-70% less than young forests in the stand re-initiation or stem exclusion stages.

Succession and Nutrition

Foresters and ecologists have long-known that the growth of forests decreases as they age; however, the causes for the age-related decline have remained a mystery until recently. What is emerging is an interesting story that suggests the decline in forest growth, and other age-related functional changes, are because of the changes in stand structure.

Most notable is the dramatic changes in the nutrient cycles of forests during succession because of the changes in litter quality. Except for forests growing in heavily polluted areas, forests derive the bulk of their annual requirement of nutrients from minerals released from decomposing leaves, branches, stems and roots.

During the early stages of succession a high proportion of the litter is comprised of leaf tissue which, compared to branches and stems, is more easily decomposed by decomposers because of its greater nutrient concentration. In the later stages of succession however, the annual production of tissue falling to the forest floor is comprised of more woody tissue (e.g. branches and stems resulting from the self-thinning stage). Woody tissue decomposes slower than foliage by a factor of 10 to 100, resulting in nutrients being sequestered (locked up) for decades in the branches, twigs and stems.

Numerous studies have shown that nitrogen may limit growth in mature conifer forests while several recent studies suggest that calcium and potassium may limit growth of mature northern hardwood forests. The steady decline in nutrient availability during succession adversely affects leaf photosynthetic rates and causes trees to grow more fine roots and less foliage and stem wood.

A second possible cause for the decline in tree growth during succession is related to greater constraints of transporting water to the top of the tree and end of the long branches in mature trees. Just as it is more difficult to suck water through a long versus short straw, trees have a more difficult time providing water to the very tops of the canopy of mature trees. To compensate for the inefficient plumbing, large trees have a more conservative water balance. If water transport up the stem cannot keep pace with water loss from the canopy (this process is called transpiration) the tree suffers irreparable water stress. Therefore, to avoid permanent damage mature trees restrict the opening of the pores on leaves (stomata) where carbon dioxide is absorbed into the leaf for photosynthesis, and water is lost from the leaf to the atmosphere.

In summary, it seems likely that nutrient and water transport constraints may be responsible for the decline in tree growth during succession and both of the constraints are directly or indirectly related to changes in the structure of the forest during succession.

Impact on Forest Management

Understanding forest succession is very important when we make forest management prescriptions. On some sites it is often easier to work with the natural progression and maintain one of the late successional stages than it is to maintain an early stage.

When harvests are prescribed, heavier cuts cause, in general, greater disturbance to the natural succession process than do light selection cuts. Therefore, if you are hoping to regenerate certain species naturally following a harvest, it is important to know what successional stage these species typically occupy; and, what type of harvest will generate the desired conditions for stand establishment.

What can woodland owners do to minimize the decline in forest growth in aging stands? The most obvious solution is to reduce the rotation length of the forest. Another option might be to fertilize the forest to prevent a nutrient limitation; however, this approach is not inexpensive and in many cases would not be cost-effective. Finally, landowners can minimize the reduction in growth by managing forests such as northern hardwoods (sugar maple, yellow birch, basswood and hemlock) on an uneven-aged basis. Uneven-aged management, while not appropriate for all species, does maintain a balance of healthy, vigorous trees and a smaller number of mature trees.

PennState Extension

What Is Heartwood in Trees?

The dark-colored area of a tree is called heartwood, and the lighter-colored area is called sapwood. What causes this change in color in the wood, and how does it affect the wood properties?

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Board showing heartwood and sapwood

If you look at the cross-section of a stump from a tree that was cut down, there is almost always a portion of the cut surface that appears darker than the rest of the surface. The dark-colored area is called heartwood, and the lighter-colored area is called sapwood. What causes this change in color in the wood, and how does it affect the wood properties?

The darker heartwood is always found in a zone around the center of the tree and is surrounded by a lighter-colored zone called sapwood. The size of the two zones varies by tree species and even between trees of the same species. Some species, like black cherry and black walnut, tend to have a large heartwood, while others, such as sugar maple, tend to have a relatively small heartwood. The sapwood portion of the tree is the only place where living cells are found within the tree itself and is where sap is transported up the tree. All cells in the heartwood are dead and movement of liquids does not occur.

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As a young tree grows and cell division takes place in the cambium layer, the walls of the created cells eventually begin to thicken and become lignified. Lignin is a substance that gives the cell wall rigidity and helps to bind cells together. As the cell walls thicken, most of the cells die, although some retain their protoplasts and carry on metabolic processes in the sapwood. These cells are known as parenchyma cells and serve as storage cells within the tree, acting as a reservoir for photosynthates the tree makes. As these living cells get further away from the outside layer of the tree, they also begin to die.

When the trees are young there is no heartwood in them. Heartwood begins to form between fourteen and eighteen years old, although this can vary among species. The process of how the heartwood forms is a bit of a mystery, and a review of the literature shows that not everyone agrees on the exact process that contributes to the formation of the heartwood. However, the production of various compounds, broadly called secondary metabolites, is believed to be a contributing factor. Secondary metabolites are substances that are not directly involved in the normal growth and development of the tree. These metabolites accumulate in cell walls as well as the lumen (the center part of the cell) and are usually polyphenolic in nature.

Polyphenols that are commonly found in trees include oils, resins, gums, tannins, and aromatic and coloring substances. Some of these secondary metabolites can be extracted from the heartwood through various processes, so they are collectively referred to as extractives. It is believed that these extractives are formed from metabolites transported by the living parenchyma cells located near the heartwood/sapwood boundary. Metabolites, unlike secondary metabolites, are products of processes that are directly involved with the normal growth and development of the tree.

Heartwood formation is often associated with a decrease in water content found in the cells. The columns of water in the tree are believed to be under tension, and eventually, these water columns will form an embolism, or an obstruction, preventing the movement of liquids through that portion of the tree. These embolisms are more likely to occur the further away from the ground the wood is. This may be one reason why the roots of trees tend to have very little heartwood in them.

The basic structure of heartwood and sapwood cells are the same and it is mainly the chemical extractives that differentiate the two types of wood. It is the extractives that give heartwood several properties that are different from sapwood.

One difference in properties is the darker color associated with the heartwood in most trees. Most polyphenols that are formed by the trees are colorless in regular light, but they can degrade over time. The death of the parenchyma cells that they are found in allows them to diffuse into the wood, where they oxidize and become darker.

Another property that is different between heartwood and sapwood is the ability to resist decay or insect attack. It is known that some species of trees have a much greater resistance to rot. Black locust, which makes great fence posts, is one example of this. The main reason it makes great fence posts is due to its ability to resist fungal attack. Cypress, redwood, and cedar are other examples of trees that have heartwood that is highly resistant to rot. The ability of the heartwood to resist rot depends on the type of extractives that are found in the heartwood. The heartwood of some trees contains high levels of extractives that resist rot, while others have little or none. The sapwood of all tree species is susceptible to rot because it contains no extractives.

Heartwood of certain species may be difficult to penetrate with liquids such as chemicals used for preservative purposes. This resistance can be caused by several things, including the presence of extractives such as oils, waxes, and gums. These types of extractives can plug up the tiny openings in the cell lumen and walls, effectively hindering the movement of liquids. Other types of extractives can block openings in the cell walls from progressive deposition over time.

The distinct odor that some trees exhibit, such as cedar, is usually due to a type of extractive called aromatic extractive compounds.

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It is believed that some of these aromatic compounds play a role in defending against certain insects.

Heartwood and sapwood are the same but different. They have the same cell structure but have several different properties that can make one species more suitable for a certain application than another. The chemical compounds found in the heartwood can make certain species more aesthetically pleasing and more valuable, such as black walnut, or it can make them less prone to rot, such as black locust.

Authors

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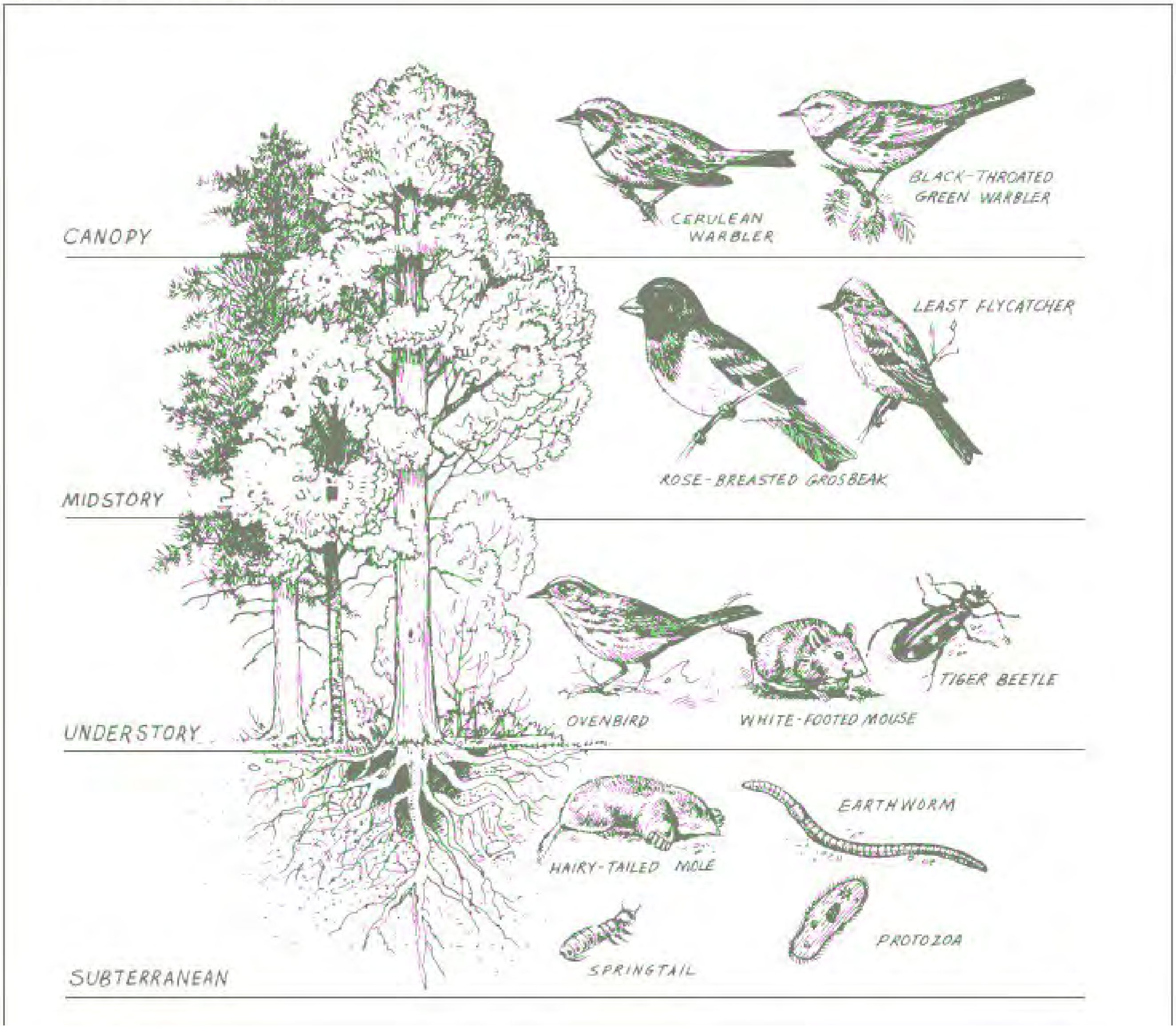
Expertise

- Wood Products
- Kiln Drying Lumber
- Maple Syrup
- Forestry

Vertical Forest Stratification

Diversity in vertical structure.
The vertical arrangement of vegetation in a forest is as important to many species as the size of the forest itself. Introduced wildlife species are dependent upon different vegetative layers in the forest—subterranean, understory, midstory, and canopy layers. (See Figure 2.) Each layer offers a unique set of habitat features. Fallen logs, snags, and cavity trees also add to vertical structure and enhance biodiversity. (See Pennsylvania Woodlands #6 in the Forest Ecology section of this CD).

Figure 2. Vertical stratification



Tree Classifications

The canopy trees compete with each other for sunlight. The position of a tree crown affects how well a tree grows relative to its closest competitors. Trees that get the most sunlight generally grow fastest. Tree crowns are classified as *dominant, codominant, intermediate* or *suppressed*.

- **Dominant** trees have crowns that rise above the general canopy level. they get full sunlight form above and on all sides.

- **Codominant** trees make up the average canopy level. Their crowns receive overhead light but surrounding trees restrict some sunlight from the sides.
- **Intermediate** trees occupy a position underneath the dominant and codominants below the general crown canopy. They receive sunlight only from directly above.
- **Suppressed** trees receive no overhead sunlight. They usually are slow-growing and weakened.

Shade tolerant tree species can grow in the suppressed level of the canopy or in the understory for many years and then, upon the death of a tree overhead, they respond with a spurt of growth to take their place in the general canopy.

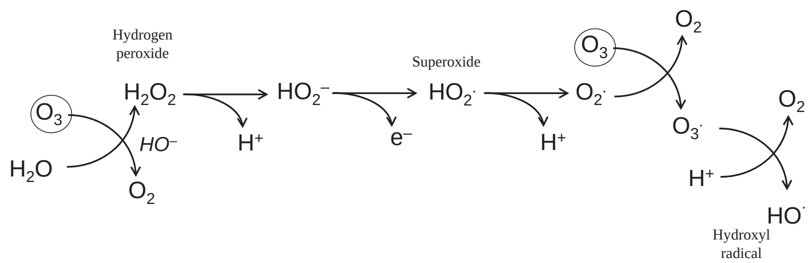


Fig. 2. Ozone reactions and electron structure of some products of O_3 and water. Adapted from Jans & Hoigné (2000) and Walcek *et al.* (1997). Many of the chemical species have unpaired electrons associated with the compound, which makes them highly reactive. In addition, some species can easily take up a proton from water, depending upon the pH of the medium, which alters its characteristics and reactivity.

Movement of reaction product(s) into the cell and enzymatic or chemical transformations within the cell

It is believed that the initial site of O_3 damage is the plasma membrane. Membrane functions, such as membrane fluidity (Pauls & Thompson 1980), permeability (Elkiey & Ormrod 1979), K^+ exchange *via* ATPase reactions (Dominy & Heath 1985) and Ca^{2+} exclusion (Castillo & Heath 1990) are rapidly lost. If O_3 reacts with components of the cell wall, those alterations may connect to the cytoplasm through the wall and mem-brane by membrane-specific proteins not directly linked to transport. The similarity of wounding responses (Langebartels *et al.* 1991) and O_3-induced membrane disruption suggests the induction of wound-regulated genes (Mehlhorn *et al.* 1991).

After the normal physiological homeostasis is disturbed, attempts of re-normalisation occur within cells and between tissues, with activation of genetic responses. Most of these studies are recent due to the great strides in genomics and centre upon pathogen response (PR) activity and senescence (discussed later). The production of defence compounds (antioxidants) is an energetically costly response, and they increase under elevated O_3 (Sheng *et al.* 1997; Tausz *et al.* 1999, 2002). In mature Jeffrey pine, stomatal uptake of O_3 elicited one complex of antioxidant defences in mesic microsites, while endogenously-generated free radicals in the chloroplast elicited a second complex of antioxidant defences in xeric microsites (Grulke *et al.* 2003b).

Mesophyll cells of leaves receive the products of O_3 with water and wall- or membrane-linked biochemicals. Arguments have been made about the types of chemicals which can be formed (Heath 2007), yet none have been well proven to exist within the leaf except for hydrogen peroxide (H_2O_2), which is also made by the leaf cell. In alkaline media, O_3 reacts and forms H_2O_2 and many other compounds (Fig. 2). In acid media, O_3 is relatively stable in the absence of metal ions. The pH of the cell walls within the substomatal cavity is more acid than alkaline, but the wall does have diverse charges and sur-faces, which may alter these simplified conclusions.

From the reaction coefficients given by Atkinson (1990), the rates of reaction of O_3 with double-bond compounds includes: the Creigee mechanism (equation 1), ring breakage *e.g.* ascorbate (equation 2) and sulphydryl oxidation (equation 3; see Heath 1987).

$$\text{R-CH}_2\text{-CH=CH-CH}_2\text{-R}' \rightarrow \text{R-CH}_2\text{-CH(OH)} + \text{O=CH-CH}_2\text{-R}' \quad (1)$$

$$\text{C-Ring with [double bond]} + O_3 \rightarrow \text{Broken C-ring at [double bond]} \quad (2)$$

$$\text{G-SH} + \text{G-SH} + O_3 \rightarrow \text{G-S-S-G} + H_2O + O_2 \quad (3)$$

Reactions with double bonds and with sulphydryl groups have been seen to alter protein structures and thereby inactivate them.

While many reactions could occur and alter some metabolites, most pathways are well regulated, and for any small disruption, the pathway would tend to return to near its former stability. Thus, many measurements of metabolites or even enzymes may result in undetectable changes due to the smallness of the change and experimental variability. The most accurate measurement of changes is the flow of metabolites through a pathway, and those measurements are difficult at best.

Hydrogen peroxide

In the past, H_2O_2 was thought to be a toxic compound for cells as there are so many antioxidants and enzyme systems that eliminate it. However, it is clear that cells generate it for specific purposes, notably to attack invading pathogens in defence (Mehdy 1994; Simon-Plas *et al.* 1997). In fact, it is believed that the chemical species generated is superoxide through a one-electron reduction of molecular oxygen (reactive oxidative species, ROS). In the acid region of the cell wall, superoxide is immediately converted to H_2O_2 by a protonation and dismutation. That conversion is carried out by NAD(P)H oxidase located on the cell membrane, facilitated by cytochrome b6 (Auh & Murphy 1995). Furthermore, H_2O_2 is used for oxidation in lignification (Schopfer 1994; Schopfer *et al.* 2001). The induced oxidative burst by ROS likely plays a role in stimulating Cl^- and K^+ efflux, and in generating alkalinisation of the extracellular space, since these processes are inhibited by preventing the burst (Cazale *et al.* 1998).

In the wall region, H_2O_2 is not that toxic as no necrosis is reported when 500 mM peroxide is infiltrated into leaf tissue.

However, the production of salicylic acid and benzoic 2-hyroxylase are induced with 30 and 0.3 mM H_2O_2, respectively, indicating some metabolic signalling (Leon *et al.* 1995). A 1 M H_2O_2 solution infiltrated into soybean will generate lipid peroxidation after 1 h (Degousee *et al.* 1994). The cells can react to the total system and generate peroxide scavenging compounds within a few hours, which eliminate excess H_2O_2 (Baker *et al.* 1995).

Hydrogen peroxide has been found in the wall after O_3 exposure in silver birch (Pellinen *et al.* 1999, 2002). By using $CeCl_2$ as a cellular stain for H_2O_2 (as a cerium perhydroxide precipitate, see Liu *et al.* 1995), a gradual development of stain was found after 8 h of an acute O_3 exposure. Ozone itself may induce some formation of H_2O_2, and so an additional 25 min passed after exposure for it to be dissipated with the expectation that any O_3-induced H_2O_2 would be eliminated by reactions with apoplastic antioxidants. After 2 h of exposure, H_2O_2 staining was visible on the surfaces of both sets of mesophyll cells. Accumulation of H_2O_2 stain continued for 16 h after the exposure, suggesting a triggered reaction rather than O_3 decomposition itself. There was H_2O_2 stain present in the mitochondria, peroxisomes and cytoplasm, but not in the chloroplast. These experiments indicate that O_3 *per se* does not generate the H_2O_2 but rather triggers a stress-related H_2O_2 formation similar to pathogen attack (ROS). Ozone breakdown can also add more H_2O_2. The presence of higher than normal levels of H_2O_2 within the apoplastic space implies a stimulation of the normal pathogen defence pathway. Thus, all the events and activation of pathways/genes caused by pathogen defence should be observed upon O_3 exposure of plants.

Hydrogen peroxide has been linked to abscisic acid (ABA, a hormone)-induced stomatal closure by activating Ca^{+2} influx in guard cells (Pel *et al.* 2000). The addition of H_2O_2 to a guard cell preparation at a level of only 5 mM will cause a dramatic increase (ca. 9×) in membrane current (due to ion flow) at the hyperpolarising potential of −200 mV. Amounts as low 50 μM H_2O_2 will also cause a sizable current increase. While the membrane stability was unaffected by H_2O_2, the activation of the channel required only about 23 min. Abscisic acid also induced the production of H_2O_2 through ROS accumulation (see Shapiro & Zhang 2001). A recessive ABA signalling mutant (gca2) showed insensitivity of stomatal closure to the hormone, and a lack of stimulation of the Ca^{2+} influx. On the other hand, H_2O_2 inhibits ABA-induced stomatal closure. Thus, a model of interactions that links H_2O_2 with ion flux, and ABA production with an inhibiting signal molecule of ABA-insensitive gene 2 (ABI2, equations 4, 5):

$$H_2O_2 \rightarrow [Ca^{2+}\text{influx and ABA production}] \quad (4)$$

$$\text{ABA} \rightarrow \text{stomatal closure [but inhibited by ABI2]} \quad (5)$$

In the past it was not understood why, in some cases, O_3 would not always decrease stomatal conductance (see Heath 1994b). The phospho-tyrosine-specific protein phosphatase (ABA-insensitive gene 2) is an inhibitor of stomatal closure induced by ABA but is inhibited by H_2O_2 (Meinhard *et al.* 2002). The sensitivity of stomatal closure to ABA is modified by H_2O_2 to make the stomatal complex more sensitive to the hormone. Thus, for a given level of ABA present in the guard cell complex due to environmental factors such as low humidity, soil water potential or high air temperature, any generation of H_2O_2 would inhibit ABA-insensitive gene 2 and increase stomatal closure *via* increased sensitivity to the hormone.

Photosynthesis inhibition: Alteration of mRNA coding of Rubisco by O_3

There is a large body of literature that shows that O_3 can induce declines in cellular concentrations of Rubisco (Pell *et al.* 1994). Treatment of a variety of plants with a moderate level of O_3 induces a loss of Rubisco due to reduced mRNA coding for both subunits of Rubisco. With the important role of Rubisco in the production of carbohydrates (see Fig. 3), any loss could have severe consequences for plant productivity.

The sequence of the formation and functional activation of Rubisco is a useful example of genomics, and serves as a model for linking genomics, plant physiology and ecology. While it may seem that assaying the Rubisco mRNA would predict O_3 injury, there are many events that will change the production of Rubisco mRNA.

For example, the level of carbohydrate influences the amount of mRNA for Rubisco (*rbc*S). As stated in Krapp *et al.* (1993), there are four indications of this: (i) removal of a sink organ leads to an inhibition of assimilation at the source; (ii) given an increased level of CO_2, after a transitory increase in assimilation, the rate returns to that measured previously; (iii) using transformed cells to prevent sucrose export (the addition of invertase to the cell wall) leads to an increase in sugar content and a decline in assimilation; (iv) sugars fed through the transpiration stream lead to a decline in assimilation. This may partially explain why total productivity of a leaf may not reflect functioning area of the leaf.

Williams *et al.* (1994) developed a correlation between ABA levels after drought stress in thale cress leaves and the loss of Rubisco mRNA. The ABA level had a half-life rise time of about 1–2 h, and the Rubisco mRNA level had a half-life decline of about 2–4 h. This suggests that drought stress may alter the relationships much more than merely closing the stomata. If ABA lowers Rubisco mRNA by whatever mechanism, it may be a poor marker of O_3 exposure except under very controlled conditions.

Carbohydrate transformations and allocation

Many of the experiments with O_3 have shown that exposure reduces the net assimilation (the balance of carbon gain and loss through assimilation and respiration) and accumulated dry mass of the plant. If the stomata close partially, photosynthetic activity will decline which should lower carbon gain, which in turn will reduce growth. However, fixed carbon alone does not account for the complete equation. Repair or prevention of injury (antioxidant response) requires resources and energy, which additively reduces growth, but little work has been done on the amount of energy so diverted and its ramifications.

Adams *et al.* (1990) found that there was 'no statistically significant effects of elevated O_3 (up to 95 nl $O_3 \cdot l^{-1}$ for 7 h) on either carbon gain or photosynthate at any specific time during the growing season'. In the same study, he reported that

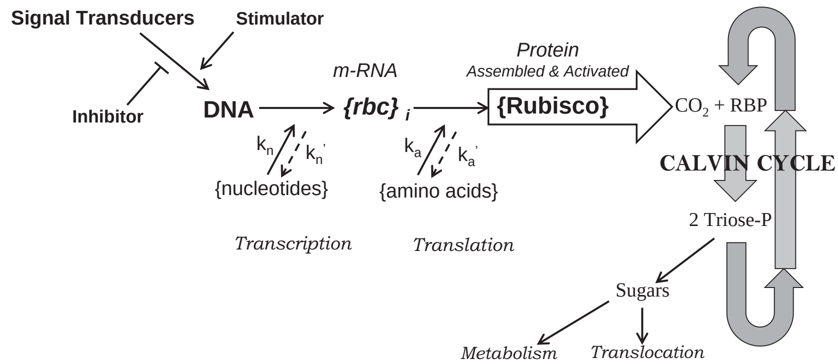


Fig. 3. The formation and use of Rubisco following the Central Dogma Sequence. DNA produces mRNA, which is the code for the protein structure(s). With Rubisco, two distinct subunits must be produced and assembled to make a working protein. The stimulation of the DNA–RNA sequence is controlled by a number of signal transduction agents, which alters the ability of DNA to be transcribed. Rubisco is the key enzyme in the Calvin Cycle of photosynthesis, which fixes a CO_2 molecule into sugars (ribulose 1,5-bisphosphate carboxylase/oxygenase). The CO_2 enters the leaf through the stomata, which has a conductance.

loblolly pine seedlings grown at twice ambient O_3 levels consistently exhibited lower assimilation, higher respiration and a reduction of allocation to the fine roots. It is likely that high plant-to-plant differences in response belied statistical discovery. On the other hand, Volin *et al.* (1998) reported lower leaf area, leaf weight, specific leaf area and root weight in trembling aspen and two C_3 grasses (western wheatgrass. *Agropyron smithii,* now *Pascopyrum smithii* (*Rydb.*) *À. Löve* and prairie Junegrass, *Koeleria cristata,* now *Koeleria macrantha* (Ledeb.) Schult.), but not in red oak or C_4 grasses (side oats grama, *Bouteloua curtipendula* (Michx.) Torr. and little bluestem, *Schizachyrium scoparium* (Michx.) Nash). There was no statistically significant change in any species in leaf stomatal conductance nor in assimilation. They described a correlation over all species between growth decline and increased stomatal conductance, which may be an example of loss of stomatal control at high O_3 exposures (see above).

Maximum concentrations of carbohydrates in 1-year-old ponderosa pine needles declined with an increase in pollution (O_3 and N deposition) along an anthropogenic pollution gradient east of Los Angeles, CA (Grulke *et al.* 2001). Monosaccharide concentrations in fine roots were depressed, along with starch, suggesting that needle sugars were limiting and that led to root sugar limitations as well. No attempt was made at balancing the total productivity since the data were taken over a full growing season of mature trees with many source–sink interactions. In a shorter-term exposure (9 days; Smeulders *et al.* 1995), low O_3 exposure increased the retention of labelled photosynthates within the needle (see Grantz & Farrar 2000), but at higher exposures (400 *versus* 200 or 0 nl $O_3 \cdot l^{-1}$), total starch within the needle declined, suggesting that less carbohydrate was produced within the cells.

There is a pronounced reduction in the allocation of carbohydrate from shoot to root, with the shoot maintaining a larger proportion of carbon recently fixed. In cotton, Grantz & Yang (2000) found that the O_3-mediated allocation differed from that driven by foliar loss (pruning). Ozone triggers a plant-wide response, possibly regulated by long-distance signals that modify the delivery of resources to these sinks in parallel. Stitt (1996) suggested that '. . .allocation is regulated by long-distance signals that act to influence growth of selected sinks and to modify the delivery of resources to these sinks in parallel'. Cooley & Manning (1987) further suggested that there were three possible ways that O_3 exposure might alter translocation: (i) malfunction of the phloem loading process; (ii) increased allocation to repair damage within the source; and (iii) altered balance between source and sink.

Ozone exposure can induce a shift in the carbon transfer between roots and shoots, which is amplified by mild drought (Gerant *et al.* 1996). Further, wounding the leaves of red goosefoot (*Chenopodium rubrum* L.) induced defence responses, which also regulated source–sink relations (Roitsch 1999). Ethylene (C_2H_2, discussed below) can repress the expression of extracellular invertase, which is critical for control and downloading of sucrose derived from the translocation stream.

Although inhibition of phloem loading into the stem has been reported with O_3 exposure (Grantz & Farrar 2000), it is unclear whether or not sugars are translocated out of the leaf. Dugger & Ting (1970a) suggested this nearly 40 years ago, but few have returned to this question. Some observations suggest that assimilation within the leaf declines, translocation is inhibited even more so, such that fewer growing points of the plant are stimulated to grow and root/shoot ratios are altered (Tjoelker *et al.* 1995; Gerant *et al.* 1996).

MISSISSIPPI STATE UNIVERSITY™
EXTENSION

Longleaf Pine Through Time: How Centuries of Change Shaped a Forest and the Effort to Manage it

Introduction

Historically, the longleaf pine (*Pinus palustris*) forest extended for approximately 92 million acres across the southeastern United States, from the Piedmont region to the Gulf Coastal Plain, and from Virginia to Texas (**Figure 1**). It was one of the most important species in different ecosystems—such as savannas, woodlands, and forests—supporting a complex web of life and human livelihoods for millennia. The presettlement area covered by longleaf pine could be divided roughly into two major categories: 74 million acres of longleaf-dominant stands and 18 million acres of mixed-species forests containing longleaf pine.

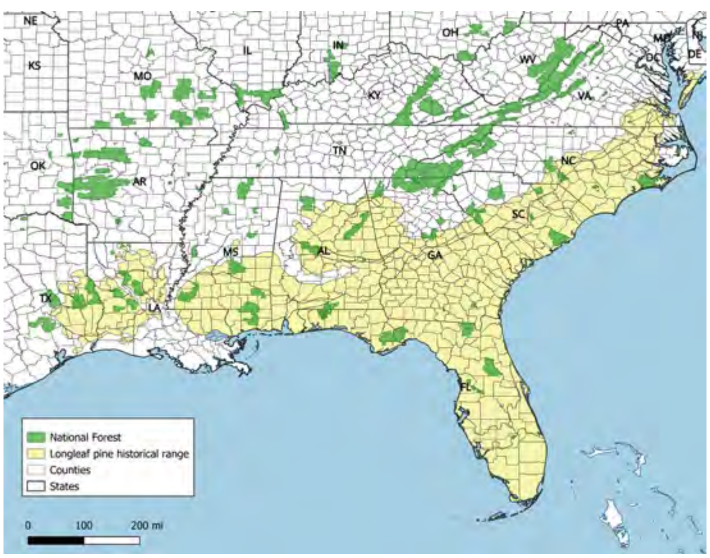


Figure 1. Longleaf pine historic and current range.

The primary longleaf pine forest was one of the most expansive and ecologically rich ecosystems in North America. Longleaf pine is a fire climax species, depending on frequent low-intensity fire to maintain its dominance (**Figure 2**). Longleaf pine seedlings evolved to resist flames, thriving in sandy, well-drained soils; without fire, hardwoods and other pine species would quickly outcompete longleaf. Natural disturbances like hurricanes and lightning were part of the forest's renewal cycle, ensuring continuous canopy cover and regeneration.

Figure 2. Longleaf pine seedling during prescribed fire.
Photo by John Maxwell, U.S. Fish and Wildlife Service/Flickr.com

However, less than 4 percent of the original longleaf range remains intact today, due to logging, fire exclusion, and land use change. Very few old-growth longleaf remnants exist only in four of the nine longleaf states (Alabama, Florida, Georgia, and North Carolina), and some ecosystem types, like Piedmont or West Gulf Coastal Plain, have no remaining representatives of the primary forest. Fortunately, a growing interest in restoring longleaf for wildlife habitat, climate resilience, and cultural heritage is sparking renewed efforts across public and private lands (**Figures 3 and 4**).

This publication aims to track the origins and decline of the longleaf pine ecosystem from a historical and social point of view. By understanding the ecological, cultural, and industrial factors that shaped this landscape, landowners, natural resource professionals, and longleaf pine enthusiasts can make more informed decisions about restoring and sustaining longleaf pine habitats today.

Figure 3. Longleaf pine at the University of Southern Mississippi's Lake Thoreau Environmental Center in Hattiesburg, Mississippi.

Figure 4. Longleaf pine on private forestland in Allen Parish, Louisiana.

Stewards of the Fire Forest: Native Americans and the Pre-European Settlement

Prior to European colonization, the longleaf pine thrived as a dynamic, fire-maintained ecosystem characterized by frequent, low-intensity surface fires, ignited by lightning or intentionally set by Indigenous peoples. Fire maintained an open canopy of widely spaced trees above a diverse herbaceous ground layer rich in grasses, legumes, and forbs (**Figures 5 and 6**). It supported some of the highest levels of plant species richness in North America. Species such as gopher tortoise (*Gopherus polyphemus*, **Figure 7**), red-cockaded woodpecker (*Picoides borealis*, **Figure 8**), Bachman's sparrow (*Peucaea aestivalis*), and numerous native plants evolved alongside this fire regime.

Figure 5. A diverse, open, and fire-maintained longleaf pine understory near Picayune, Mississippi. Species like pitcher plants (*Sarracenia* spp.), meadow beauty (*Rexia* spp.), swamp lily (*Hymenocallis occidentalis)*, white bog orchid (Platanthera nivea), and various grasses and sedges contribute to this colorful and vibrant ecosystem. *Photo by Patricia Drackett*

Figure 6. Pine lily (*Lilium catesbaei*) blooming in a longleaf pine understory near Picayune, Mississippi. *Photo by Patricia Drackett*

Figure 7. Gopher tortoise (*Gopherus polyphemus*). *Photo by Tom Friedel/Birdphotos.com*

Figure 8. Red-cockaded woodpecker (*Picoides borealis*). *Photo by er-birds/Inaturalist.org*

The longleaf pine forest profoundly shaped the lives of Indigenous peoples in the southeastern United States, though the details of their earliest interactions with the forest are lost to history. Drawing from early European accounts, we know that Native Americans depended on the forest for shelter, fuel, tools, ceremonial materials, and hunting grounds. They used longleaf pine heartwood for fires, pine bark for building structures and paving village paths, and lightwood splinters for illumination. Hunting techniques also revolved around fire. Deer, abundant in the open pine woods, were hunted using strategic fires that drove the animals from dense bottoms into the open where hunters lay in wait. Fire use extended to spiritual and cultural practices as well: soot mixed with bear oil served as ceremonial paint, and longleaf wood played a role in funeral rites. Fire was a critical land management tool, preparing the land for the crops and keeping the understory structure open. It was indeed an important cultural and environmental force.

Although Native Americans harvested resources and made clearings, they did not significantly alter the forest; in fact, their frequent use of fire helped maintain its open structure. When European settlers arrived, they encountered a longleaf ecosystem shaped in part by centuries of Indigenous stewardship. William Bartram, an American naturalist, writer, and explorer, offered one of the most detailed and sympathetic accounts of Southeastern tribes and the longleaf ecosystem. He described the landscape as open, breezy, and beautiful. He observed Indigenous use of fire, agriculture, architecture, and social customs; he documented their diets, tools, and kinship with the land. Welcomed by leaders during his travels, Bartram witnessed a way of life that was rapidly changing due to European influence, including the adoption of metal tools, livestock, and new crops.

Despite these moments of cultural exchange, the trajectory of Native–European relations was overwhelmingly destructive. The longleaf pine belt, once shaped by centuries of Native American stewardship, was left largely in the hands of European settlers. By the early 19th century, only a few Indigenous groups remained in the Southeast; among them were the Choctaw in Mississippi, the Creek in Alabama, the Croatan in North Carolina, and the Seminole in Florida. Yet despite centuries of cultural upheaval, the physical longleaf forest still stood largely intact when settlers took full control.

European Arrival in the Longleaf Belt

With the arrival of European settlers, the landscape underwent rapid transformation. Settlers suppressed fire to protect homesteads and livestock, began clearing forests for agriculture, and harvested trees for lumber and naval stores (tar, pitch, turpentine). The first Europeans to enter the longleaf pine forests were Spanish explorers. They were focused more on conquest than colonization; they left much of the Gulf Coast interior largely untouched during their 256-year control from 1565 to 1821, preserving the forests in near-pristine condition.

Other European settlers, such as English, Irish, Scottish, and French Huguenots were fleeing persecution and hardship in search of religious freedom, economic opportunity, and land of their own. They were motivated more by homesteading (and colonization) than conquest. Driven by commercial interests, they aggressively sought to domesticate and use the land, especially along accessible waterways from Virginia to Texas.

Native Americans taught them how to hunt, clear land with fire, identify edible plants, and cultivate corn and other crops suited to the sandy soils. They valued longleaf pine for its straight, dense, and rot-resistant wood. They learned from Native Americans to use fire for managing grazing areas, while helping to maintain the open forest structure. Fire continued to play a role in the homestead economy, used to improve pasture forage quality and to clear the land of nuisances such as snakes, ticks, and chiggers (**Figure 9**).

Figure 9. Prescribed fire in longleaf pine at the University of Southern Mississippi's Lake Thoreau Environmental Center in Hattiesburg, Mississippi. *Photo by Butch Bailey*

Though settlers cleared more land than Indigenous peoples, they generally preferred the richer soils of bottomland areas, sparing large tracts of the longleaf uplands. Observers like Bartram and John F. Claiborne recorded the vast, open pine forests of the Southeast, while historian Nollie Hickman described Mississippi's piney woods as a pastoral economy shaped by grasslands and wild game, where livestock and wildlife thrived in harmony with the enduring forest. Communities gradually grew along rivers, which served as primary transportation corridors. Mills, shops, and taverns sprung up to support a thriving backcountry economy based on livestock, naval stores, and timber.

Pineywoods Cattle

Settlers hunted the native bison, which roamed the longleaf pine forests and grazed the carpet of grasses under the trees, and then replaced them with cattle and other livestock. The cattle brought by Spanish settlers were small and allowed to roam freely in a semi-wild state. They quickly became self-sufficient and hardy, while still retaining their gentle temperament. Their long and curved horns (rakestraw) allowed them to rake through longleaf pine straw to uncover grass, a skill especially useful in winter, when grasses grow beneath the litter for protection from frost.

Among the American cattle breeds, Pineywoods cattle are one of the oldest, descending from Spanish cattle brought to the Southeast in the 1500s. Over centuries, they adapted to the challenging environmental and cultural conditions of Alabama, Mississippi, and Georgia. Hardy, parasite-resistant, and productive on marginal forage, they became deeply entwined with the rural culture of the Deep South—based in growing and producing to provide for families' needs.

Historically, Pineywoods cattle were raised in open-range systems by people who also practiced timberland farming to survive. Logging camps and sawmill towns relied on Pineywoods oxen for transport, while families relied on large herds that grazed across public and private lands. Herding was mostly hands-off, with minimal feeding or veterinary care. Cattle were vital not only for milk, meat, and hides but also as a form of wealth and cultural identity.

The introduction of tractors and "improved" breeds in the 1950s began to displace these traditional systems. Stock laws passed in the 1960s closed open-range grazing, forcing many families to sell off their herds. Despite this, a handful of dedicated breeders preserved distinct strains, such as the Conway, Carter, Broadus, Baylis, and others (**Figure 10**). The Pineywoods Cattle Registry and Breeders Association and other conservation efforts, supported by the American Livestock Breeds Conservancy, are now working to document, promote, and sustain these cattle as vital living remnants of Southern agricultural and cultural heritage.

Hogs

Introduced by Hernando de Soto in 1539 and later multiplied by English settlers, hogs quickly spread through the region. They reached high densities and inflicted sustained ecological damage, particularly by consuming seeds and destroying seedlings. Census and anecdotal data suggest that by the mid-18th century, hog densities had reached carrying capacity in many areas, with the animals completely depending on wild forage, including the starchy roots of longleaf seedlings. These seedlings, highly visible and palatable in the grass stage, were consumed in large numbers, leaving few chances for forest recovery.

Figure 10. Pineywoods cattle near Poplarville, Mississippi.
Courtesy of Jess Brown, Cowpen Creek Farm.

The destructive impact of hogs on longleaf pine regeneration went largely unnoticed until after the Civil War, when large-scale steam logging rapidly removed the virgin forest and revealed the failure of natural regeneration. For centuries, the dense overstory had masked the ecological damage caused by open-range hogs, which had long roamed freely across the South. The sudden loss of forest cover exposed the widespread absence of seedling recovery, prompting a reevaluation of land use and fencing practices.

Historically, crops were fenced to protect them from roaming livestock, but the post-war timber shortage made this practice increasingly impractical. In response, many southern states began passing stock laws in the 1870s, reversing the fencing burden and now requiring livestock owners to confine their animals. These laws marked a turning point in forest and agricultural management, gradually reducing hog pressure on regenerating woodlands. Though implementation was uneven and slow across the region, this shift laid the groundwork for improved longleaf pine recovery by curbing one of its most persistent threats.

Figure 11. Feral hogs at Grand Bay National Estuarine Research Reserve in Moss Point, Mississippi.
Photo by Jonathan Pitchford

Fencing hogs out of regeneration plots dramatically improved seedling survival, while unfenced areas consistently showed near-total failure of longleaf regeneration, as demonstrated by later research in the 20th century. Other livestock like sheep and goats caused damage, too, but they did not come close to the destructiveness of hogs. In contrast to earlier misconceptions that blamed fire for regeneration failure, this evidence shifts attention to feral swine as the most lethal obstacle. Their consistent rooting of longleaf seedlings, especially during key establishment years, likely played a crucial role in the species' historical range contraction (**Figure 11**).

Naval Stores

During the 17th century, longleaf pine forests were a primary source of naval stores, products including tar, raw turpentine, and their derivatives (spirits of turpentine, rosin, and pitch) supplied to the British Royal Navy to waterproof vessels. Contrary to claims that the industry began in North Carolina, Virginia was producing tar and pitch from longleaf pine as early as 1608, exporting barrels from Jamestown Colony (**Figure 12**).

Tar was produced by burning branches and logs in slow-burning kilns, while pitch was obtained by boiling tar. Spirits of turpentine and rosin were distilled from raw turpentine, the resin secreted by pines when scarified, or cut. To collect the resin from longleaf pine trees, workers cut a cavity (called a box) into the base of the tree. Above the box, they made narrow, V-shaped streaks

Figure 12. The turpentine industry in North Carolina. Appeared in *Harper's Weekly* (April 9, 1887). *From Original Prints, Audio Visual Materials, Special Collections, State Archives of North Carolina/Flickr.com*

across the tree's face using a hook-bladed tool known as a hack (**Figure 13**). These cuts stimulated the flow of resin, which was collected in the box. Each week during the growing season, new streaks were added to maintain the flow. Once the box was full, the resin was scooped into pails and transferred into barrels for transport to the distillation still.

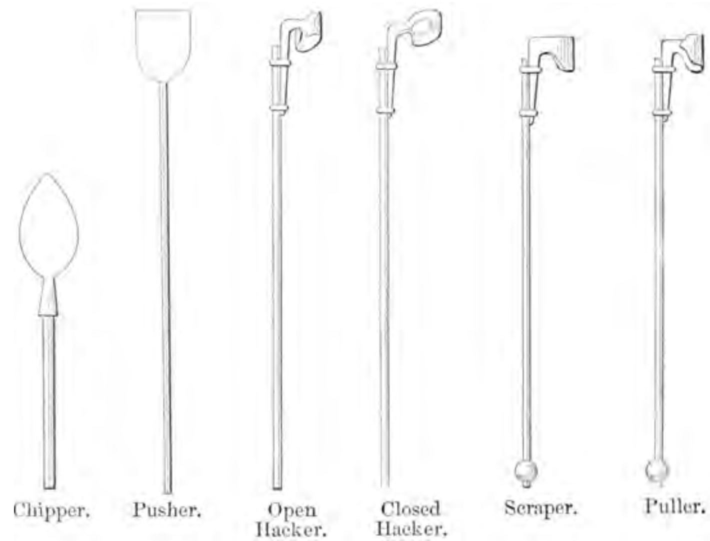


Figure 13. Tools used in the turpentine industry in 1896. *Photo by Popular Science Monthly (1896)/Archive.org*

Naval stores workers, primarily people of African descent, lived in company-run camps where they obtained food, clothing, and supplies from commissaries. Within this labor system, workers developed specialized roles. The most respected were the chippers, who skillfully cut the resin-producing streaks on trees. Lower-status tasks, often assigned to women and children, included dipping and hauling the resin. White supervisors, known as woods riders, managed the crews and were paid a daily wage. Labor recruitment was competitive and contentious; operators fiercely guarded their workforce, and attempts to lure workers from rival camps ended violently.

Figure 14. A turpentine still in North Carolina. *Photo by Littleton View Co. from* The New York Public Library

Tar was also used as a lubricant, rust protectant, wood preservative, and antiseptic. Turpentine was used as a solvent, external rub, laxative, and insect repellent; it was also used to waterproof leather and cloth. Rosin was used in papermaking, as an ingredient for soap, as a floor covering, and as paving material. North Carolina had become the principal supplier of naval stores to England during the colonial period, with significant turpentining activity along the Tar River and throughout the Coastal Plain. Introduction of the copper still in 1834 revolutionized the industry, enabling efficient distillation of spirits of turpentine and extending commercial exploitation across the South. By 1840, North Carolina dominated U.S. naval stores production, supplying nearly 96 percent of the nation's turpentine and rosin (**Figure 14**). During the colonial period, American naval stores had already become England's main source. By 1850, North and South Carolina together produced 95 percent of all American naval stores.

By the 1850s, naval stores were still North Carolina's leading commercial product, but intensive harvesting had devastated the state's longleaf pine forests. Longleaf forests were heavily damaged by boxing, which weakened trees and made them vulnerable to fire and wind. Producers pushed south into Georgia and Florida, and by the late 1800s, naval stores operations expanded westward into Alabama, Mississippi, and Louisiana. However, the industry declined as it moved west, facing competition from the growing lumber sector. After the Civil War, southern public lands were once again opened for homesteading and sale, accelerating forest exploitation.

1700–1900: The Agricultural and Industrial Conversion

European settlement gradually expanded inland from the Atlantic Coast beginning in the 1730s, reaching the Appalachian foothills by the late 1700s. Between 1750 and 1850, most fertile longleaf pine uplands were cleared for farming or pasture, especially in the Piedmont and Black Belt regions. While the coastal areas and uplands of Alabama, Mississippi, and east Texas remained largely untouched into the early 1800s, land cessions and U.S. expansion after 1821 rapidly opened these areas to cotton plantation agriculture. By 1900, nearly a third of the original longleaf pine uplands had been converted to farmland, marking a major shift in land use and the beginning of longleaf pine's large-scale decline.

The invention of the cotton gin in 1793 sparked another wave of transformation. Cotton cultivation expanded rapidly, and many longleaf forests were cleared for plantations. From the early 1600s to the mid-1700s, logging had limited impact on longleaf pine forests due to its primitive labor-intensive nature. Logs were moved with animal power and only in proximity to waterways. Water-powered sawmills, introduced in the early 1700s, expanded lumber production, but mills still relied on slow, reciprocating (back-and-forth) blades and seasonal water flow. Logging remained local and small-scale, with plantation sawmills primarily serving nearby needs.

When the Civil War erupted, most Southern settlers in longleaf country sided with the Confederacy. After the war, the region lay devastated: plantations destroyed, forests cut, and economies shattered. Some landowners struggled to rebuild by selling off forested land to speculators and logging companies. Other settlers moved west to start fresh, living simply off the land with livestock, gardens, hunting, and fishing.

After the Civil War, aggressive logging of longleaf pine emerged as a major economic driver in the South. Early timber operations depended on rivers for transportation and mill power. Trees were felled with axes and floated downstream to water-powered, and later steam-driven, sawmills. These mills, often owned by better-financed operators, advanced supplies to loggers in exchange for timber deliveries. This created a dependent labor system. Oxen teams and hand-dug ditches extended the reach of logging into nearby forests, though the range was still limited to areas close to navigable waterways. Despite its challenges, this river-based logging era had a relatively modest environmental footprint, leaving interior forests largely untouched.

This changed dramatically with the rise of railroad logging at the turn of the 20th century. Spur lines and mechanized equipment allowed clearcutting of vast tracts of longleaf pine. By the early 1900s, most of the region's old-growth stands had been harvested, and with little planning for regeneration, these areas were often left as barren "stumpscapes." The combination of industrial-scale harvesting and the absence of sustainable forestry practices led to the near-complete loss of the once-dominant longleaf pine ecosystem across much of its native range.

By the end of the 19th century, industrial logging had emerged as a dominant force in the South, marking a dramatic shift in the longleaf pine ecosystem. Spurred by the depletion of northern forests and a booming demand for yellow pine lumber, railroads, steam-powered skidders, and mechanized mills replaced earlier, more localized and selective logging practices (**Figure 15**). This new era brought rapid clearcutting across millions of acres, fundamentally altering the landscape and pushing the longleaf pine forest toward near collapse.

Figure 15. Transporting pine logs from Louisiana to Texas by the Sabine Tram Company. *Photo by C. E. Walden from the Book of Texas (1916)/Flickr.com*

World Wars, Industrial Logging, and the Struggle to Restore the Longleaf Pine Ecosystem

Lumber towns sprang up to support the operations of massive sawmills, some becoming permanent communities, others vanishing as the forests disappeared. Meanwhile, naval stores production evolved with the introduction of the cup-and-gutter system, which replaced the destructive boxing method and gained wide use after 1910. Fires were set to protect valuable turpentine faces, which were V-shaped cuts made in the bark of pine trees to collect sap for turpentine production. However, these burns often destroyed newly germinated longleaf seedlings unless timed to coincide with good seed crops. World War I brought new urgency and demand. Southern lumber fueled the construction of army barracks, railcars, and even wooden ships.

Despite setbacks like labor shortages and timber scarcity, many ships were built until steel construction took over. In the rush to meet demand, most loggers gave little thought to forest regeneration. Encouraged by tax policies and profit motives, the industry largely adopted a "cut out and get out" approach. However, a few pioneering foresters, such as Austin Cary, Henry Hardtner, and Herman Chapman, advocated for sustainable practices. Despite isolated efforts, the vast longleaf pine forest was nearly gone by 1930. Railroad loggers moved west to harvest Douglas fir and redwood, leaving behind exhausted land and abandoned mills. In just four decades, the longleaf pine's reign as the South's dominant forest type had come to a dramatic and devastating end.

During the Great Depression, the longleaf pine region suffered deeply: mills closed, towns emptied, and cutover lands lay barren. Desperate residents and forest workers survived on abandoned lands with little support, making a living through small garden plots and subsistence livestock. The Civilian Conservation Corps (CCC), launched in 1933, brought relief by employing young men to plant trees, fight wildfires, and build infrastructure. Their labor helped create national forests like De Soto in Mississippi and Kisatchie in Louisiana (**Figure 16**), laying the groundwork for restoration.

During the 1930s, a fierce debate erupted in the South over the role of fire in forest management, particularly in the longleaf pine ecosystem. For generations, cattlemen, naval store workers, hunters, and farmers had used fire as a routine land management tool to improve forage, ease travel, drive game, and manage pests. Fire was essential to maintaining the open, grassy structure of longleaf forests. But northern-trained foresters launched a vigorous campaign to eliminate fire, viewing it as universally destructive, based on the catastrophic crown fires frequent in other regions. Early forestry institutions and state laws began criminalizing woods burning, while fire prevention programs, lookouts, and propaganda efforts tried to sway public opinion.

A group of Southern ecologists and pioneering foresters, including Chapman, Cary, Herbert Stoddard, and "Cap" Eldredge demonstrated that prescribed fire was essential for longleaf regeneration, disease control, and habitat management. By the mid-1930s, studies by the Southern Forest Experiment Station confirmed the benefits of prescribed fire for disease control, seedbed preparation, and ecological health. A turning point came with the 1935 Society of American Foresters meeting, which endorsed careful prescribed burning. This paved the way for its cautious adoption on national forests and marked a major shift in U.S. forestry—a recognition that fire was not merely a threat but a vital ecological and silvicultural tool in the longleaf pine ecosystem. Prescribed burning gained momentum, culminating in broader U.S. Forest Service approval by 1943. The acceptance of fire as a management tool became a turning point in longleaf pine restoration. Rather than viewing fire solely as a threat, foresters increasingly recognized its critical role

Figure 16. Longleaf pine at the Palustris Experimental Forest within the Kisatchie National Forest in Rapides Parish, Louisiana. *Photo by Preston Keres, U.S. Forest Service Photography/Flickr.com*

in regenerating the longleaf ecosystem, a legacy that continues to shape management today.

A second-growth longleaf pine forest slowly emerged from the previous devastation, though it covered only a fraction of the original range and was often poorly stocked. In many cases, regeneration occurred accidentally, helped by unplanned events like hurricanes, favorable seed years, and the occasional absence of disturbance factors like hogs. Foresters like "Red" Bateman helped protect advance regeneration, but vast tracts of former longleaf land were lost permanently to agriculture, hardwood encroachment, or conversion to other pine species.

The industrial infrastructure of the first forest was replaced by a more localized, mobile timber economy based on rubber-tired trucks, small skidders, and portable sawmills. Though less grand in scale, the second-growth timber economy still supported thousands of rural Southerners, many of whom were part-time farmers. Naval stores persisted for a time but eventually shifted to slash pine regions. The last economic yields from the virgin longleaf came in the form of stump harvesting for rosin and turpentine. Open-range grazing also declined, becoming more regulated and better integrated with forest management. Despite fragmentation and lower productivity, this second forest marked a critical transitional phase in the longleaf pine story, one shaped by both ecological chance and human adaptation.

During World War II, fire control was critical due to threats posed to military installations and local communities. With limited equipment, crews relied on steel lookout towers, hand tools, and coordinated backfires to manage wildfires. Forest product output was targeted toward military needs like ammunition boxes and crating. New technologies, such as chain saws, boosted the mills' efficiency and productivity, and new infrastructure provided access to remote timber resources. These wartime forestry efforts kept the longleaf pine region vital to the national defense.

Postwar and the New Millennium: Decline and Revival of Longleaf Pine

Despite research efforts focused on secondary forest management, ecological complexity, fire dependence, advanced prescribed fire, and regeneration techniques, many foresters decided to abandon longleaf pine. Fueled by widespread regeneration failures, millions of acres of secondary longleaf pine were lost to conversion to loblolly and slash pine.

By 1900, pine plantations were virtually nonexistent in the South, with only a few small farmer-led plantings. The U.S. Forest Service's first large-scale attempt in 1911 (900 acres on Choctawhatchee and Ocala National Forests) largely failed, and by 1919, only 500 acres were known to be successfully established. However, as planting techniques improved, the scale of plantations began to grow. By 1931, more than 20 lumber and paper companies had taken up pine planting, accounting for most early commercial plantations.

By the 1960s, a new wave of industrial logging targeted the second-growth forests. Clearcutting, windrowing, and mechanical site preparation often led to type conversion. Longleaf was replaced with loblolly or slash pine, making longleaf pine the unpopular choice. The expansion of fire-excluded areas made loblolly and slash pine plantations increasingly viable. As development pushed timber operations into more marginal lands, intensive plantation management for pulpwood and sawtimber became widespread.

As the U.S. Forest Service and private landowners adopted Smokey Bear-era fire suppression strategies, fire-dependent species and ground layers disappeared. Invasive hardwoods took over, and fuel loads built up to dangerous levels. The species' decline continued as many foresters lacked knowledge of its management potential, and regeneration failures reinforced the perception that longleaf was too risky to invest in.

However, between the mid-1960s and early 1980s, longleaf pine research in Brewton, Alabama, led by a team of dedicated foresters and scientists, emerged as a central force in the species' recovery. Brewton launched a major regional shelterwood study across the longleaf belt, from North Carolina to Louisiana, testing regeneration techniques and documenting the ecological responses. These tests, supported by national forests, state agencies, and private industry, generated crucial insights into seedling survival, fire management, site preparation, and regeneration strategies.

The Brewton team also engaged directly with practitioners through workshops, guiding national forest prescriptions, and collaborating with industry partners. Their results helped shift attitudes toward longleaf pine, which had become unfavorable due to regeneration failures and competition from faster-growing species. Innovations in site preparation, planting techniques, seedling grading, and technologies improved survival rates dramatically. Despite setbacks such as drought and poor stock handling, the research highlighted that longleaf could be reliably regenerated with proper methods. By the early 1980s, this persistent, science-based outreach had reversed longleaf pine's decline and laid the groundwork for a broad-scale restoration movement.

The Contemporary Era of Longleaf Pine: Restoration, Research, and Resilience

By 1990, the historical longleaf pine region had been dramatically altered, with only an estimated 2.9 million acres of longleaf remaining, and approximately 15.3 million acres of pine plantations dominated by loblolly and slash pine. The longleaf pine, once dismissed as too difficult and slow to regenerate, was gradually regaining favor due to growing awareness of its ecological and economic potential (**Figure 17**).

Figure 17. Prescribed fire in longleaf pine at the University of Southern Mississippi's Lake Thoreau Environmental Center in Hattiesburg, Mississippi. *Photo by Butch Bailey*

Despite being overshadowed for decades by faster-growing plantation species, longleaf pine began to attract renewed interest among private landowners, conservation organizations, and public agencies. This shift was driven in part by a deeper understanding of its ecological significance and its compatibility with low-input, long-rotation forestry systems. Longleaf's resilience to fire, hurricanes, pests, and drought—especially important in an era of increasing climate variability—positioned it as a species well-suited to sustainable land management.

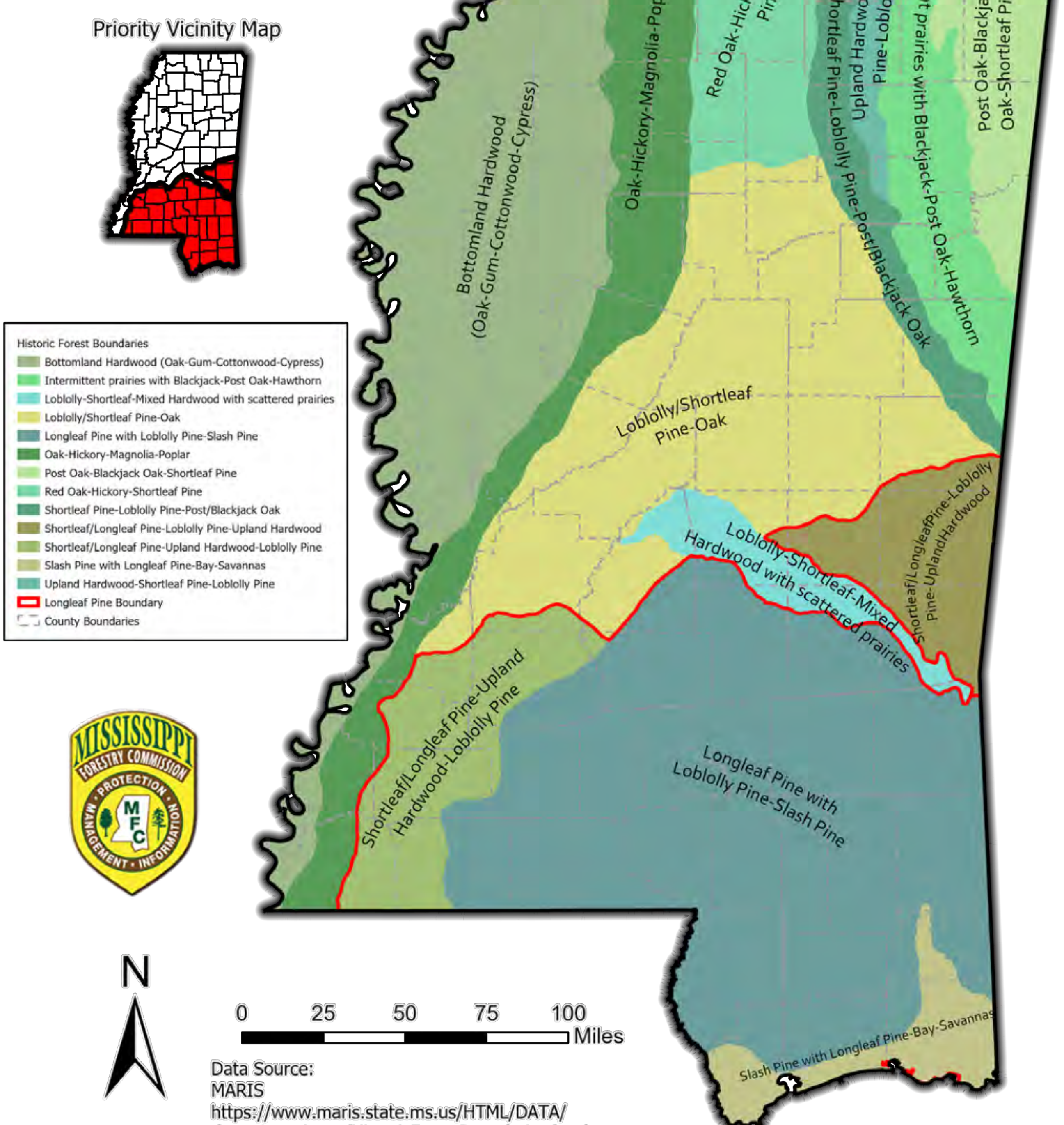
Substantial advances in silvicultural techniques enabled more reliable longleaf regeneration. Improved containerized seedling technology, better genetic selection, mechanized planting tools, and refined site preparation techniques significantly boosted survival rates. Public-private initiatives like the Longleaf Alliance, the U.S. Department of Agriculture's Longleaf Pine Initiative, and partnerships with several agencies, such as the Department of Defense and the National Fish and Wildlife Foundation, fueled restoration efforts and encouraged longleaf planting on both working lands and conservation properties.

Longleaf's timber qualities (dense, straight grain and natural rot resistance) remained preferred for poles and high-grade lumber, while its open, grassy understory supported rich biodiversity, attracting wildlife and hunting enthusiasts. In addition, its cultural symbolism and aesthetic appeal made it a favored landscape for recreational properties, heritage sites, and agroforestry systems (**Figure 18**).

Figure 18. Crafting longleaf pine needle baskets. *Photo by USDA National Agroforestry Center*

By the early 21st century, longleaf pine was no longer seen solely as a relic of the past but as a viable and valuable species for the future. Restoration efforts have expanded across the South, with growing recognition of the role of longleaf pine in achieving climate resilience, fire-adapted landscapes, and integrated working lands strategies. Ongoing research and education continue to drive interest in longleaf pine as both a functional forest type and a symbol of Southern conservation.

Mississippi Historic Forest Boundaries



Forestry Study Resources

Key Topic #3: Plant Communities

11. Describe the role of fire in ecosystems (including fire-dependent and non-fire-dependent systems).

Resource Title	Source	Located on Page
Conditions for Conducting Prescribed Burns	*USDA Forest Service. (n.d.). Prescribed burning in Louisiana Pinelands.* *https://www.lsuagcenter.com/~/media/system/1/3/a/4/13a46c80fc2cf898f100e51f5bf1dde2/pub1618prescribedburninginpinelandslowres.pdf*	56
Living with Fire: A Guide for Mississippi Homeowners	*Carree et al. (n.d.). Living with Fire: A Guide for Mississippi Homeowners.* *https://extension.msstate.edu/sites/default/files/publications/P2315_web.pdf*	58

Conditions for Conducting Prescribed Burns

For the stand and fuel conditions described above, here is an outline of the desired conditions for prescribed burning to accomplish the objectives sought.

1. Season of Year

There are two seasons for prescribed burning (summer and winter), and sometimes summer burning weather occurs in winter. Generally, summer burning conditions prevail from June through October and winter ones from November through March. Ordinarily, no burning should be done in April or May because of possible harm to the young of many wildlife species.

Fuel reduction burns are mostly done in winter. For hardwood control in immature pine stands, winter burns are preferred. In older stands and just before harvesting, summer burning may be done. Site preparation burns are best done in hot, dry weather, preferably late summer. Brownspot control burns are made in winter.

2. Fuel Conditions

Hardwood leaves carry fire poorly, so pine needle fuel is required to successfully carry fire over the area. This means an overstory of pine greater than 30 square feet of basal area per acre. The only way to successfully burn over the mixed pine-hardwood stand properly is to use hotter fire conditions: dry fuel and high wind velocity. An exception would be an open stand with scattered waxmyrtle and considerable grass on the ground. Fire will move readily through this fuel.

For most purposes, the surface fuels should be relatively dry (10% to 30% moisture content) and the lower layer on top of the soil moist to dry. The soil should be damp.

3. Weather

a. Days since last rain - It takes at least 1/2 inch of rain to halt prescribed burning and, even then, after passage of a cold front, a burn may sometimes be made the next day. Generally, burning may be done from one to 10 days after a rain. A wet-site fuel may take three weeks to dry out. Ordinarily, after about 10 days without rain most fuels are too dry to burn without excessive damage to the standing pines.

b. Relative humidity - The safe and effective range is from 30% to 60%. Occasionally, when a hot burn is mandatory, a reading of 20% may be all right. Conversely, a safe burn may not be possible in a very young plantation unless the humidity exceeds 80%.

c. Air temperature - With certain notable exceptions, this factor is not as important as it once was. Fuel moisture and wind velocity are the governing factors for most burns, so a wide range of temperatures (from 40 degrees to 80 degrees F) may be suitable. Exceptions are the careful winter burn in young stands and the hot site-preparation burn in summer.

d. Wind direction and velocity - The ideal condition is a strong, steady wind from the north-northwest. Often, however, conditions are less than ideal. After the north-northwest winds, the south-southwest ones are the most dependable. Avoid the variable winds from some easterly quarter. Wind velocities ranging from 3 to 10 miles per hour, at eye height in the stand, serve most burning purposes. Determine wind speed with a portable anemometer. Finally, never try to burn when there is no wind at all. The fire will not move properly, and excessive butt and crown scorch will result.

4. Time of Day

Most prescribed burning is done in the daytime (from 10 a.m. to 6 p.m.) when weather and working conditions are favorable. Night burning may be required in (a) very young stands, (b) stands where draped fuel is a real problem or (c) where there is slash on the ground as from thinning. This is because night air tends to be cooler, humidity is higher and fuels are moister.

5. Type of Fire

a. Backfire - Fire is set on the windward side of a control line and allowed to back into the wind. Since rate of backing seldom exceeds 100 feet an hour, interior firelines must be prepared and fires set along them rapidly to get the area burned over in the available burning period. Backfiring is not flexible; it requires stable weather. It is relatively easy and safe to do and causes minimum scorch. Backfires are used mainly for fuel reduction and hardwood control.

b. Strip headfire - A downwind control line or burned area is established first, then short strips of headfire are allowed to run with the wind. How far apart the strips are spaced depends on wind, fuel and desired results. Strip headfire can be used in cool weather when humidity and fuel moisture are relatively high and wind velocity is low. It requires fewer plowed lines and is faster and cheaper. It is flexible and allows some change in direction of firing to meet changes in wind direction. It is used in winter for brownspot control and fuel reduction and in winter or summer for hardwood control. Caution: Inexperienced burners should always use backfire until they gain the knowledge and skill to use strip headfire or flank fire.

c. Flank fire - In this method, fire is set directly into the wind and burns slowly at right angles to the wind. It may also be used on the flanks of any fire to secure them as the fire progresses. Flank fire burns hotter than backfire and cooler than headfire. It requires a constant wind direction. No interior fire lines are needed. It requires experienced personnel and good crew coordination. It is used in medium fuels or in larger timber, usually in winter, to speed the job or to supplement some other burning method.

d. Spot fires - After a downwind control line has been established, a series of spot fires 30 to 100 feet apart are set in rows, fired and spaced as in strip headfiring. The result is a checkerboard of fires that burn in all directions and eventually draw together to cover the whole area. A large area can be burned in a short time, but this method of firing takes care and skill to execute. It can be used only in uniform fuel and relatively large timber. Few plowed lines are needed. Considerable variation in wind direction can be tolerated. Use in cool weather.

6. Fire Intensity and Flame Height

Depending on purpose of the burn and type of fire used, a wide range in severity may be tolerated.

Winter burns to reduce fuel in young stands should be low intensity with flame height less than 3 feet. Wildlife burns to remove litter in older stands work best under similar conditions.

Living with Fire: A Guide for Mississippi Homeowners

More than 18 million acres of Mississippi are covered with forestland. About half of this acreage is either pine or a pine/hardwood mix. Located within these pine and pine/hardwood forests are many houses, subdivisions, and communities. As more people move to and build within these forests, the chance of loss or damage from wildfire increases. While large wildfires are uncommon in Mississippi, the conditions for such fires do occur. Many homeowners living in these areas are unaware and unprepared for a wildfire. Since it is not a question of "if" but rather "when" a wildfire will occur, the likelihood of human and property loss is great and constantly growing.

Being able to live safely with fire depends on things you do before a wildfire occurs. These pre-fire actions will not fireproof your home or forests, but they will increase the likelihood of escaping both personal injury and property damage. This publication provides information on the fire environment in which we live, as well as pre-fire actions you can take to protect your home and property from wildfire damage.

The Fire Environment

Fire environment can be defined by surrounding conditions and influences that determine wildfire behavior. Firefighters recognize three parts of the fire environment: weather, topography, and fuels.

Weather includes wind, rain, temperature, relative humidity, and clouds. Weather directly affects wildfire by influencing how wet or dry a fuel is, whether a fire will start, and the speed and direction the fire moves. Another part of assessing the fire environment is the "lay of the land," or its topography. This includes both slope and terrain, as well as bodies of water across the landscape. All of these will affect the amount and type of fuels present, as well as how fast and in what direction fire spreads.

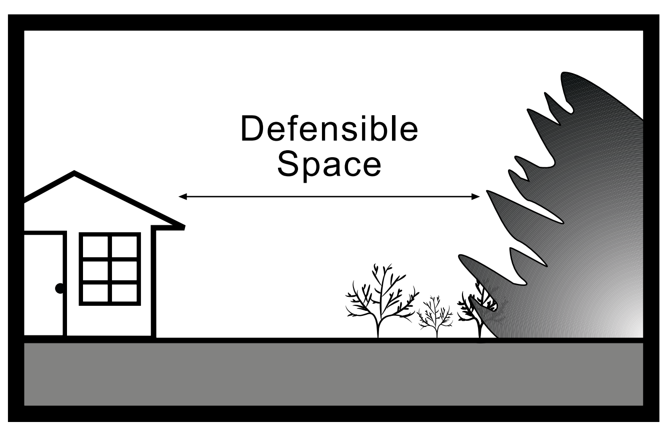
Fuels are anything that will burn, including leaves, grasses and weeds, downed woody materials like branches and tree trunks, living shrubs and trees, manmade debris across the landscape, and even structures like houses. Houses and other buildings become a source of fuel when fires occur. The amount, size, shape, composition, distribution, and moisture content of fuels will affect fire behavior.

Together, weather, topography, and fuel affect the likelihood of a fire, the speed and direction it will travel, the intensity at which it will burn, and the ability to control and extinguish it. You cannot change weather and topography, but you can control the threat of wildfire through fuel management.

Defensible Space

Defensible space is the area between a house or other structure and an oncoming wildfire. You can change plant cover in this space to reduce the threat of wildfire and to help firefighters defend your house. Bare ground surrounding your home is not necessary. Well maintained grass, shrubs, and trees can effectively reduce the threat of wildfire, while maintaining the appearance of the home.

For the most part, you can create defensible space yourself. Watering your lawn, pruning shrubs and trees, selecting appropriate plants, and providing irrigation will help keep plants green and healthy. Tools needed for these activities are simple items found around most homes: saws, water hoses, rakes, pruning shears, and shovels.



Six Steps to Creating an Effective Defensible Space

Adapted from Carree et al., 1998, and P. Slack, (n.d.).

Step 1: Determine the slope and vegetative cover of your land.

The amount of defensible space you need for your property varies depending on slope of the landscape and vegetation present. The steeper the slope, the faster a fire can spread and the larger defensible space you need. Also, vegetation will affect how a fire burns and the amount of defensible space needed. **Table 1** lists defensible space recommendations based on percent slopes and common vegetation types in Mississippi.

Step 2: Remove dead vegetation.

Dead vegetation includes dead trees and branches lying on or close to the ground, dried grass, dropped leaves and needles, and stacks of firewood. In most instances, dead vegetation should be removed from defensible space areas. **Table 2** describes the types of dead vegetation you're likely to encounter and recommended actions.

Step 3: Break up continuous vegetation.

Sometimes wildland and landscaped plants grow as an uninterrupted layer instead of being patchy or widely spaced. The more continuous and dense the vegetation, the greater the threat of wildfire. If this condition is present in your defensible space, you should "break it up" by creating a separation between plants or small groups of plants.

Step 4: Remove "ladder fuels."

Vegetation often grows and/or accumulates at varying heights, similar to the rungs of a ladder. This is common in loblolly pine plantations, where dead lower branches become draped with pine needles. Under these conditions, flames from fuels burning at ground level can be carried higher up the tree through these ladder fuels. Vegetation that lets fire move from lower areas to higher ones (from a surface fire to igniting the crown of the tree) is called "ladder fuel." You can correct this problem by removing those ladder fuels.

Within a defensible space, a vertical separation of three times the height of the lower fuel layer is recommended. For example, if a shrub growing close to a pine tree is 3 feet tall, the recommended distance between the shrub and the lowest limbs on the tree would be 9 feet. You can achieve this separation by pruning lower tree branches.

Table 1. Defensible space recommendations (in feet) based on vegetation type and slope percent.

Vegetation type	Flat to gently sloping (0–20%)	Moderately steep (21–40%)
Grass	30	100
Shrubs	100	200
Trees	30	100

These recommendations are based on suggestions made by firefighters experienced in protecting homes from wildfire. They are not requirements and do not take precedence over local ordinances.

Table 2. Dead vegetation types and recommended practices for the creation of defensible space.

Dead fuel type	Recommended practices
Standing, dead trees	Remove all standing, dead trees from within the defensible space area.
Downed, dead trees	Remove all downed, dead trees within the defensible space if they have recently fallen and are not embedded in the ground. Downed trees that are embedded and cannot be removed without soil disturbance should be left in place. Remove all exposed branches from embedded, downed trees.
Dead shrubs	Remove all dead shrubs from the defensible space area.
Dried grasses	Once grasses have dried out (cured), remove from the defensible space area.
Dead needles, leaves, branches, and cones (on the ground)	Reduce thick layers of pine needles to a depth of 2 inches or less. Do not remove all needles. Take care not to disturb the duff layer (dark area at the ground surface where needles are decomposing), if present. Remove dead cones, twigs, leaves, and branches.
Dead needles, leaves, branches, and cones (other than on the ground)	Remove all dead leaves, branches, twigs, and needles still attached to living trees and shrubs to a height of 15 feet above the ground. Routinely remove all debris that accumulates on roofs and in rain gutters.
Firewood and other combustible debris	Locate firewood and other combustible debris (wood scraps, grass clippings, leaf piles, and such) at least 30 feet away and uphill, if possible, from the house.

Step 5: Maintain at least 30 feet around your house that is lean, clean, and green.

The area immediately next to your house is very important in creating an effective defensible space. It is also an area that people typically landscape. Within an area at least 30 feet adjacent to the house, vegetation should be kept:

Lean: Small amounts of flammable vegetation.

Clean: No accumulation of dead vegetation or other flammable debris.

Green: Plants that are healthy and green during the fire season are less likely to burn.

Step 6: Maintain vegetation within your defensible space.

Maintaining your defensible space is a continual process and key to keeping your fire-prevention efforts effective. At least once a year, review these defensible space procedures and take appropriate actions.

Other Ways to Protect Your Home from Wildfire

Keep these additional considerations in mind:

The roof: Remove dead branches overhanging the roof. Remove any branches within 15 feet of your chimney. Clean all dead leaves and needles from your roof and gutters. Use nonflammable roofing materials.

Construction: Build your home at least 30 feet away from the property line. Use fire-resistant building materials. Limit the size and number of windows in your home that face large areas of vegetation. Install double- or triple-paned windows. Install sprinkler systems within the house. Do not use wooden shingles or siding on your home.

Yard: Stack wood piles at least 30 feet from all structures and clear away flammable vegetation. Locate propane tanks at least 30 feet away from all structures and keep 10 feet of clearance around them. Remove all combustible materials and other debris from your yard. Keep grass mowed and green.

Emergency water supply: Have enough water hoses in good condition to cover your lawn. Keep an emergency water supply that meets fire department standards. If your water comes from a well, consider the option of purchasing an emergency generator to operate the pump during a power failure.

Access: Identify exit routes from your neighborhood. Build roads wide enough for two-way traffic and emergency vehicles. Make sure dead end roads and driveways have enough turn-around space for emergency vehicles. Clear flammable materials and debris at least 10 feet from all roads and driveways. Make sure your street is named or numbered and that street signs are visibly posted at all intersections. Make sure your house and street number are not duplicated anywhere within your county. Post your house address at the beginning of your driveway or on your house if your house is clearly visible from the road.

Outside: Designate an emergency meeting place in a safe area outside your home and practice emergency drills. Keep electric service lines, fuse boxes, and circuit breakers maintained to code.

What to Do When a Wildfire Approaches

If your home is threatened by wildfire, you may be advised to evacuate by fire or law enforcement personnel. This recommendation is meant to protect your life and should be carefully considered. However, you can stay on your property so long as you do not hinder firefighting efforts.

Conclusions

Life in southern forests is enjoyable, but it is not without danger. Even though wildfires are not common in Mississippi, they should be planned for and not dismissed. Some counties may have ordinances addressing defensible space. Check with your local planning and zoning department for further information. Taking precautions to protect your property will increase your chances of escaping serious damage and potential personal injury or death in the event of a wildfire.

For More Information

The following references were used in the development of this publication. They provide a wealth of information concerning ways to protect your home from wildfire.

Carree, Y., Schnepf, C. & W. M. Colt. 1998. Landscaping for wildfire protection. University of Idaho, Forest, Wildlife, and Range Experiment Station. Station Bulletin 67. 15p.

Firewise. Retrieved from ***https://www.nfpa.org/Public-Education/Fire-causes-and-risks/Wildfire/Firewise-USA***

Living with fire: A guide for the homeowner. 2007. University of Nevada Cooperative Extension.

Slack, P. Firewise construction: Design and materials. Colorado State Forest Service and Federal Emergency Management Agency. 38p.

NCF-Envirothon 2026 Mississippi

Forestry Study Resources

Key Topic #4: Forests and Society

12. Analyze the economic benefits provided by forests, grasslands, and other plant communities.
13. Describe common forestry practices, including thinning, harvesting, and regeneration methods.
14. Evaluate Best Management Practices (BMPs) used in forestry and provide examples based on need.
15. Describe the different types of forest management.
16. Describe wildlife and livestock interactions on rangelands, or native grassland habitats such as prairies, including forage overlap and habitat requirements in Mississippi.

Chemicals and Products from Trees

The forest industry has made great strides in using the entire tree. Lumber, plywood and paper are essential products made from the wood fiber in trees. But up to half – or even more – of a tree is **lignin**, the complex natural chemical that binds the **cellulose** fibers in the tree together. This and other ***silvichemicals*** from trees are used in thousands of products important to people. The best part about silvichemicals is that we will never run out of them, because trees – unlike coal and petroleum sources of chemicals – are endlessly renewable with good management practices.

Turpentine and tall oil are resinous materials reclaimed from the paper pulping process. They are important ingredients in paint, varnish, adhesives, asphalt, lube-oil additives, resins, menthol, lacquer, camphor, printing inks, fungicides, rubber and latex products, soaps, disinfectants and polishes. Synthesized essential oils are used in chewing gum, mouthwash, peppermint candies and toothpaste, lime aftershave, detergents, soaps and shampoo.

Wood flour and melamine resins using cellulose filler are principle components of dinnerware, electrical receptacles and parts, toys, caster wheels, toilet seats, handles for cooking utensils, washing machine impellers, composite decks and roofs, and appliance housings. Wood flour and resins are also used as adhesives in the paper industry.

Ethyl cellulose and other chemical based cellulose are used in making tool handles, packaging films, glasses frames, molded packages, combs, brush and mirror backs, sponges, acetate filament yarns, sausage casings, cellophane, knobs and handles, luggage, gunstocks, fishing floats, toothbrushes, plastic pens, football helmets and hard hats, electrical tape, coatings, lampshades and a variety of other products. Acetate filament yarns from cellulose include rayon fiber and other textile products such as clothing, drapes and rugs. Nitrocellulose is used in making solid rocket propellants and other explosives. It is also a key ingredient in nail polish and car paint.

Torula yeast is a high-protein product made from wood sugars spent in the pulping process. It has 17 nutritional trace elements, including 4-5 times the amount of iron found in uncooked spinach or raisins. Type S Torula is used in baby foods, cereals, imitation bacon, baked goods, beverages, vegetarian food and dietary preparations. Type F Torula is used in feed supplements for cattle, hogs, fish, chickens and mink, and Type FP Torula goes into pet foods. Torula has been found to make bees and lobsters grow faster.

Lignosulfonates from spent sulphite pulping liquor are used in cleaning compounds, insecticides, cement, ceramic products, oil well drilling muds, cosmetics, artificial vanilla flavoring, gummed tape, deodorants, hair spray, pharmaceuticals such as Aldomet and Aldoril for hypertension and L-Dopa for Parkinson's Disease, fungicides, fertilizer, grouting, tanning agents for leather and a static remover for laundry. Spent sulphite liquor is also used as a binder for animal feed pellets, as an extender for molasses for liquid animal feeds, for linoleum paste, road binder and as a binder for foundry cores and ore briquettes.

From 13 to 21 percent of a cord of wood may be bark. Much of it is used as fuel in forest industry mills. Bark is also a source of chemicals such as resins, fatty acids, tannins, waxes, vitamins and tall oil. Large amounts of bark are used as mulches, soil conditioners and bedding for poultry and livestock. Other uses of bark include plywood adhesives, plastic fillers, lacquers and varnishes, molded products and oil-spill control agents.

IDAHO FOREST PRODUCTS COMMISSION

Idahoforests.org

Red-cockaded woodpecker survey report and habitat guidelines

Excerpt

The RCW survey report should include the following details:

(a) survey methodology including dates, qualifications of survey personnel, size of survey area, and transect density;

(b) pine stand characteristics including number of acres of suitable nesting and/or foraging habitat, tree species, basal area and number of pine stems 10 inches or greater per acre, percent cover of pine trees greater than 60 years of age, species of dominant vegetation within each canopy layer, understory conditions and species composition (several representative photographs should be included);

(c) number of active and inactive RCW cavity trees observed and the condition of the cavities (e.g., resin flow, shape of cavity, start-holes);

(d) presence or absence or RCWs; and

(e) topographic quadrangle maps which illustrate areas of adequate RCW nesting and/or foraging habitat, cluster sites, and cavity tree locations relative to proposed construction activities.

RCW FORAGING HABITAT ANALYSIS GUIDELINES

There are differing responsibilities of private landowners and public land managers for RCWs under the Endangered Species Act. RCW populations on public lands are required to be increasing, whereas many populations on private lands are managed for stability. Accordingly, there are two sets of guidelines for the management of RCW foraging habitat. The first, the recovery standard, is used for RCW populations on public lands or for private landowners that wish to increase the size of their population. The second, the standard for managed stability, is used on private lands for populations in which only stability is required. The standard for managed stability is not designed to increase population size nor is its wide-scale implementation within a population adequate to maintain that population's viability over the long-term. It does not provide future nesting habitat or suitable, i.e., good quality, foraging habitat over the long-term. Its wide-scale implementation will result in population fragmentation with subsequent problems related to demographic stochasticity and perhaps genetic variability. Private landowners are strongly encouraged to manage at or toward the recovery standard, but should provide at least the standard for managed stability. The standard for managed stability is as follows:

1. Provide each group of red-cockaded woodpeckers a minimum of 689 m^2 (3000 ft^2) of pine basal area, including only pines > 25.4 cm (10 in) dbh.

2. Provide the above pine basal area on a minimum of 30.4 ha (75 ac).

3. Count only those pine stands in suitable habitat that, for this standard only, has each of the following characteristics:

    a. Stands that are at least 30 years old and older.

    b. An average pine basal area of pines > 25.4 cm (10 in) between 9.2 and 16.1 m^2/ha (40 and 70 ft^2/ac).

    c. An average pine basal area of pines < 25.4 cm (10 in) less than 4.6 m^2/ha (20 f^{t2}/ac).

    d. No hardwood midstory or if a hardwood midstory is present, it is sparse and less than 2.1 m (7 ft) in height.

    e. Total stand basal area, including overstory hardwoods, less than 23.0 m^2/ha (80 ft^2/ac).

    f. We recommend that all land counted as foraging habitat be within 0.4 km (0.25 mi) of the cluster, and that any stand counted as foraging habitat be within 61 m (200 ft) of another foraging stand or the cluster itself.

    g. Frequent prescribed burning of foraging habitat, especially during the growing season, is strongly recommended. Development and protection of herbaceous groundcovers facilitates prescribed burning and benefits red-cockaded woodpeckers.

Stands cannot be considered suitable as foraging habitat unless they have an "open" character. A pine stand that is 30 years in age and has an average tree diameter of 25.4 cm (10 in) or more does not necessarily qualify as suitable foraging habitat. If such a stand has not been prescribed burned (or otherwise treated to control hardwood midstory) and has not been thinned to a basal area of 16.1 m^2/ha (70 ft^2/ac) or less, it will not satisfy the "open" condition criterion. Dense stands of young pine and pine/hardwood are typical of unmanaged plantations and natural regeneration areas (particularly loblolly seedtree harvests) that have not been thinned or frequently burned. Such stands cannot be considered suitable foraging habitat simply because they have the required total and stand basal area and average stem diameter. Stand quality, as measured by an open structure, is a critical factor determining suitability and use of foraging habitat and must be considered when acceptable foraging habitat is identified.

How to Choose and Plant a Tree

Excepts

https://www.americanforests.org/how-to-choose-and-plant-a-tree/#:~:text=Some

There are many benefits to planting a tree on your property. Trees lower your utility bills by shading your house in the summer and allowing the sun to warm it in the winter. They clean the air and absorb stormwater runoff. Trees help fight climate change, and they're even linked to better mental health.

To get all the benefits of a tree, you need to make sure you select and plant your tree so that it can thrive.

1. Consider maintenance and monitoring

Before you plant your tree, think about how you'll maintain and monitor it so that it will thrive for generations. Trees need more water directly to the roots, and not the trunk, for the first three years after planting. If you live in an arid climate, you'll need to install or extend an existing irrigation line.

Fertilizer does not fix all of a tree's problems, and many trees don't actually need fertilizer. So long as your tree is growing and its leaves look healthy, it doesn't need any extra nutrients.

Avoid using pesticides and herbicides. Many of these chemicals are linked to negative health outcomes for people, insects and birds. Herbicides intended for weeds can wind up hurting your tree.

Consult with a certified arborist if your tree is showing signs of ill health, such as yellowing or dying leaves. Oftentimes, these may be related to other issues, including over or under watering, compacted soil, too little sunlight, improper pruning, or pests and disease.

2. Choose the right spot to plant your tree

Trees have specific requirements for sunlight, soil and climate. A tree that needs full sun will not thrive if you plant it in shade, while another that needs dry soil might die if you plant it in a wet spot.

"Full sun" means at least 6 hours each day of direct sunlight. "Partial shade" means an area receives dappled shade throughout the day, or 2-4 hours of direct sunlight. "Shade" means 2 or fewer hours of sun each day.

Make sure that your tree doesn't cause problems as it grows. Plant trees at least 15 feet away from buildings so there is enough room for roots and branches to reach full size. Call the local utility company to mark any underground utilities around the planting location. Make sure that the tree won't disrupt power lines, underground utilities, sidewalks and other infrastructure as it grows.

Select a site that is far enough from your neighbor's property that the branches won't extend into their yard. Or, talk to your neighbor about the benefits of sharing the shade from your tree as it grows.

3. Select the right "climate-smart" tree

The earth's climate is changing rapidly. Some areas will experience more intense droughts. Others will weather more severe storms. Almost everywhere will be hotter. Some tree experts are now recommending that **you plant trees that are suited to the climate conditions your area will experience in 50 or 100 years**. Here are a few considerations for choosing a tree species:

- **Weather:** Pick a tree species that is tolerant to higher heat or more intense droughts. You could also consider a species that grows at a lower elevation or several miles south of your location.
- **Purpose:** Decide whether you want a shade tree, a small flowering tree to brighten up a shady corner, a tree to attract wildlife, or something else. For recommendations, you can consult a local expert (an arborist or plant nursery, for example) or the USDA's Plant Hardiness Zone Tool for your planting zone.
- **Origin:** Native trees are adapted to local conditions and provide essential habitat and food for wildlife like birds and butterflies. You can use a tool like the Audubon Native Plant Database to look up trees that are native to your area. Be careful never to plant invasive trees, including mimosa, tree-of-heaven, Norway maple and black locust. Invasive trees can compromise ecosystems.
- **Size:** When a new tree is planted, it takes several years for it to become comfortable in its new environment. The larger the tree, the more time it takes to adapt. The smaller the tree, the less time it takes to adapt. Smaller sized saplings or young trees tend to be less expensive and easier to transport and plant.
- **Season:** Fall and spring are the best times to plant a tree in a temperate climate zone. If you live in a more arid climate, winter is the best time of year to plant. Do not plant a tree in the middle of summer or a heat wave as that stresses a newly planted tree.
- **Availability:** All garden centers might not carry the tree you want. Specialty nurseries, such as native plant nurseries, may have a better selection. Call ahead or

reach out to your town or city. Some municipalities give out free or inexpensive trees, or some have tree rebate programs.

4. Carefully remove the tree from its sack or container

Do not hold the tree by its trunk, as that can cause the trunk to snap off and kill the tree. If your tree is containerized, hold onto the container and gently slide the tree out.

Do not leave the tree in bright sunlight or hot temperatures before you plant it. Instead, leave it somewhere cool in the shade. Make sure you plant your tree within 24 hours after purchase to prevent the roots from drying out.

Trees that are kept in containers for too long often have roots that grow in a circling pattern. As these wrap-around roots grow, they can “girdle” or strangle a tree. **Use your hands to loosen and tease apart the roots**. You can also take a sharp serrated knife to shave a quarter of an inch off the sides of the root ball and cut an “X” in the bottom of the root ball to help break up overly compacted roots.

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Commentary

Conservation strategies and consequences of forest fragmentation on plant biodiversity

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ABOUT THE STUDY

Forests are vital ecosystems that play a crucial role in maintaining the planet's ecological balance and sustaining life on Earth. They are home to a diverse range of plant species, providing habitat, food, and shelter for countless organisms. However, forests are facing a significant threat in the form of fragmentation and loss of plant biodiversity.

Forest fragmentation refers to the process of breaking up large, continuous forest areas into smaller, isolated patches. This phenomenon is primarily driven by human activities such as urbanization, agriculture expansion, infrastructure development, and logging. As forests become fragmented, they lose their integrity and connectivity, leading to several adverse effects on plant biodiversity.

Causes of forest fragmentation

Urbanization: Rapid urban growth results in the conversion of forested areas into residential, commercial, and industrial zones. This process often creates small, isolated forest patches within urban landscapes, disrupting plant communities and reducing their ability to thrive.

Agriculture expansion: The demand for agricultural land leads to the clearance of forests for crop cultivation. This results in the transformation of vast forested regions into fragmented patches of forests surrounded by agricultural fields, limiting plant species' access to suitable habitats.

Infrastructure development: Roads, highways, and other infrastructure projects can cut through forests, creating physical barriers that hinder plant species' dispersal and gene flow. These linear features exacerbate fragmentation and can lead to genetic isolation among plant populations.

Logging and deforestation: Unsustainable logging and deforestation practices not only reduce forest cover but also degrade the remaining forests. This degradation makes these forests more susceptible to fragmentation, as they lose their resilience and capacity to support diverse plant communities.

Consequences of forest fragmentation on plant biodiversity

Habitat loss: Fragmented forests experience a net loss of habitat area, which directly impacts plant species that rely on specific environmental conditions. Many plant species are unable to survive in smaller, isolated patches, leading to their decline or extinction.

Reduced genetic diversity: Isolated plant populations in fragmented forests often face reduced gene flow between them. This can result in inbreeding, reduced genetic diversity, and increased vulnerability to diseases and environmental changes.

Edge effects: The boundaries of fragmented forests, known as "forest edges," are subject to altered environmental conditions, including increased light, temperature fluctuations, and exposure to invasive species. These edge effects can negatively impact plant species adapted to the stable conditions of the forest interior.

Altered plant communities: Forest fragmentation can disrupt the natural composition of plant communities. Invasive species and generalist species that thrive in disturbed habitats may outcompete native, specialist plant species, further reducing overall plant diversity.

Decline in ecosystem services: Forests provide essential ecosystem services, such as carbon sequestration, water purification, and pollination. Fragmentation reduces the ability of forests to deliver these services, affecting not only plant biodiversity but also the overall health of ecosystems.

Conservation strategies

Protected areas: Establishing and expanding protected areas can help mitigate the impact of forest fragmentation by preserving large, contiguous forest tracts. These areas serve as important refuges for plant species and can facilitate genetic connectivity.

Habitat restoration: Efforts to restore degraded forest fragments can improve their suitability for plant species. This may involve planting native species, reducing invasive species, and enhancing connectivity between patches.

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Sustainable land use planning: Integrating conservation objectives into land use planning can help prevent further fragmentation. Strategic zoning, land set-asides, and regulations can help maintain larger forested areas.

Green corridors: Creating green corridors or wildlife corridors between fragmented patches can enable the movement of plants and animals, promoting genetic exchange and increasing overall biodiversity.

Community engagement: Involving local communities in conservation efforts can lead to more sustainable land management practices. Communities can play a vital role in protecting forests and supporting biodiversity conservation.

Forest fragmentation poses a significant threat to plant biodiversity, with far-reaching consequences for ecosystems and human well-being. It is imperative that we take proactive measures to address this issue through conservation efforts, sustainable land use planning, and community engagement.

Virginia Cooperative Extension
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Forest Landowner's Guide to the Measurement of Timber and Logs

James E. Johnson, Former Extension Specialist, Virginia Tech
Revised by Jennifer Gagnon, Extension Specialist, Forest Resources and Environmental Conservation

Introduction

If you are a forest landowner who is interested in selling timber, you are naturally curious about the price you will receive for your product and how that price is determined. The price is determined, in part, by how much timber you have to sell. Methods of measuring timber and the units of measurement often differ between buyers. As a seller, you should understand these methods, the units of measurement, and have an idea of a reasonable price for your timber.

Measurement of Standing Timber

The timber standing in your woodlot has a certain value, which is commonly called the stumpage value. Expressed in terms of dollars per unit volume of wood, this is the amount of money you can expect to receive when you sell your timber. Many factors determine your stumpage value, but the most important are the species of trees you have, the quality and size of the trees, the location of your woodlot, the prevailing market conditions, the terrain, and the amount of wood you have to sell. Naturally, there are great variations in stumpage prices among woodlots, depending upon changes in any of these factors. Thick, mature stands of valuable species, such as northern red oak, located on level ground near a mill, will sell for more money than stands of smaller trees of lower quality and less desirable species, located on steep terrain far from a mill.

Buyers of timber will conduct a survey of your woods before they make an offer. This survey is often called a timber cruise and involves a series of measurements of individual trees, as well as an assessment of factors that will influence the price of your timber. Such factors include the terrain, the amount of road building required, the need for culverts, the access across adjoining properties, and the need for special best management practices to protect against erosion and site deterioration after logging.

Figure 1. Forester measuring the diameter of a white oak tree using a diameter tape held at breast height, or 4 1/2 feet from the ground (Photo by Bill Worrell).

When a timber buyer measures your trees, they will locate a series of plots on your land and measure each tree on each plot. Measurements will include the diameter of the tree (figure 1), the merchantable height of the tree, the tree species, and often a subjective notation about the tree quality. The tree's dimensions, diameter, and height are used to determine the volume of the tree. It is this volume, summed over all the trees on your land, that will ultimately serve as the basis for your stumpage price.

It is at this point that the measurement of your timber may become confusing. The volume of an individual tree can be expressed in various ways, depending on the product or the buyer's preference. For example, trees sold for pulpwood (typically smaller, lower-quality trees that will be chipped) are often measured by weight, in tons. Some other, less common, units of measurement that may be used are cubic feet, cords, and cunits.

A cubic foot is equivalent to a 12 inch by 12 inch by 12 inch solid cube of wood. A cord is a stack of wood measuring 8 feet long, 4 feet high, and 4 feet wide. A solid cord, therefore, contains 128 cubic feet; however, wood is not bought and sold in terms of solid cords. When wood is stacked into cords, there is a considerable amount of air space between the pieces, so that an actual cord generally contains closer to 80 to 90 cubic feet. Another volume term sometimes used is the cunit. A cunit is simply 100 cubic feet of solid wood.

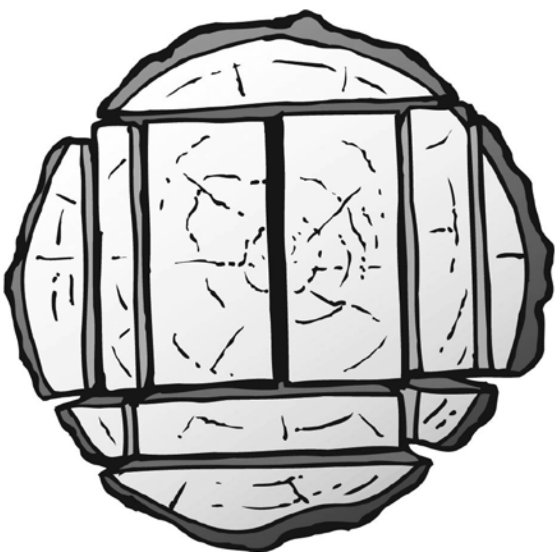


Figure 2. One way of sawing boards out of a log. The number of board feet of lumber that can be sawn from a log depends largely upon the sizes of the boards cut (Photo by T. E. Avery, from Avery, T. E., and H. E. Burkhart. *Forest Measurements*, 3rd edition. McGraw-Hill Publishing Co., New York, NY. Reproduced with permission).

The weight of your wood will not be determined until it passes over the scale at the mill. The weight of pulpwood will depend on the species, how long it has lain on the ground after being cut, and the time of year.

Even more confusing than the pulpwood measurement of your timber is the measurement of the larger trees that will become sawlogs. These larger trees, typically at least 10 inches in diameter (at a point 4 1/2 feet from the ground, referred to as breast height), are called sawtimber trees and contain significantly more value than pulpwood trees. Sawtimber trees are also measured for diameter and merchantable height, where the merchantable height is the number of 16-foot logs that could be cut out of the tree up to a minimum top diameter of 8 inches. The diameter and height are used to determine the volume of the tree in board foot units. A board foot is a piece of wood measuring 1 inch thick, 12 inches wide, and 12 inches long. The volume of a tree, therefore, is measured by the number of board feet of lumber that can be sawn out of it.

This seems simple enough, but there are many ways that boards can be cut out of logs, and thus, over the years, many ways of determining board-foot volume have evolved (figure 2). Although these rules were developed to express the volume of logs, they are also applied to standing trees that contain one or more merchantable logs. The volume of a tree is simply the sum of the individual logs that it contains.

Unfortunately, the different log rules result in different volumes when applied to logs (or trees) of the same dimension. In addition, these differences are not always consistent across the normal range of log or tree sizes. Therefore, as a seller of timber, you should be aware of these important differences so that you can compare offers based on different log rules.

General Features of Log Rules

Since the first sawmill was built in the United States, over 100 log rules have been developed, using a variety of methods. Some were based on the lumber tallies of individual mills, others were developed by diagramming the cross-section of boards in the ends of logs (figure 2), while still others were developed using mathematical formulas. In general, log rules must account for the taper that exists in all logs, saw kerf (or the loss of wood as sawdust), and a fixed procedure for removing wood on the outside of the logs for slabs. The Doyle, Scribner, and International 1/4-Inch log rules are probably the most widely used in the eastern United States.

Doyle Log Rule

The Doyle Log Rule, developed around 1825, is based on a mathematical formula and is widely used throughout the southern United States. This rule allows for a saw kerf of 5/16 inch and a slabbing allowance of 4 inches, which is about twice the normal amount. Because of this, the Doyle Rule is somewhat inconsistent; it underestimates small logs and overestimates large logs.

As a seller of timber, you must be aware that for smaller logs the Doyle Rule will underestimate the actual volume of wood that you have in your trees.

Scribner Log Rule

The Scribner Log Rule, developed around 1846, is a good example of a diagram rule. It was created by drawing the cross-sections of 1-inch boards within circles representing the end view of logs. A space of 1/4 inch was left between the boards to account for saw kerf. The Scribner Rule does not have an allowance for log taper and typically underestimates logs, particularly if the log length is long. The Scribner Decimal C is a different form of the Scribner Rule; it rounds the volumes to the nearest 10 board feet. For example, 392 board feet on the Scribner is equivalent to 390 board feet on the Scribner Decimal C scale.

International 1/4-Inch Log Rule

This rule was developed in 1906 and is based on a reasonably accurate mathematical formula. The rule allows for a 1/4-inch saw kerf and a fixed taper allowance of 1/2 inch per 4 feet of log length. Deductions are also allowed for the shrinkage of boards and a slab thickness that varies with the log diameter. Overall, the International 1/4-Inch Log Rule is the most consistent and is often used as the basis of comparison for log rules.

Comparison of Log Rules

Since each of the log rules was developed using different methods with different assumptions, it is logical that they will not always result in the same volumes for given size logs. Table 1 presents a comparison of the three log rules for 16-foot logs, with diameters ranging from 6 to 40 inches. Compared to the International ¼-Inch Rule, both the Scribner and Doyle Rules under scale logs of smaller diameters. For example, a 12-inch-diameter log contains 95 board feet on the International scale, 80 board feet on the Scribner scale, and 64 board feet on the Doyle scale. Overall, the Doyle Rule will result in lower log volumes than the International Rule, up to a log diameter of 30 inches. Since nearly all logs in Virginia are below 30 inches in diameter, for all practical purposes, the Doyle Rule will underestimate the actual board footage.

Table 1. Comparison of log rules for 16-foot logs in board feet.

Log Diameter (inches)	International¼-Inch	Scribner Decimal C	Doyle
6	20	20	4
7	30	30	9
8	40	30	16
9	50	40	25
10	65	60	36
11	80	70	49
12	95	80	64
13	115	100	81
14	135	110	100
15	160	140	121
16	180	160	144
17	205	180	169
18	230	210	196
19	260	240	225
20	290	280	256
21	320	300	289
22	355	330	324
23	390	380	361
24	425	400	400
25	460	460	441
26	500	500	484
27	540	550	529
28	585	50	576
29	630	610	625
30	675	660	676
32	770	740	784
36	980	920	1024
40	1220	1200	1296

If you are selling stumpage or logs, it is important to recognize the differences in volume associated with the different log rules. Since stumpage or log prices are based on the timber or log volume, you will receive substantially more income with the rules that scale your sizes higher. For example, consider a log measuring 16 inches in diameter and 16 feet in length, with a value of $100 per thousand board feet.

This log would have the following volumes and values based on the different log rules:

Log Diameter (inches)	Log Rule	Volume (board feet)	Value ($)
16	International ¼-Inch	180	18.00
16	Scribner Decimal C	160	16.00
16	Doyle	144	14.40

Log Rule Controversy

It is fair to say that not everyone agrees on the appropriate log rule to use. Sellers of logs and timber prefer the rules that give them the greatest return, while purchasers obviously prefer log rules that under scale the actual volume in trees or logs. It is important for you, as a seller of timber, to realize that buyers are in a risky situation. Trees and logs often have hidden defects that may greatly reduce their merchantable volume and value. With hardwood timber and logs, the quality is often a more important determinant of value than volume. A purchaser of logs must be adept at recognizing the quality of the raw materials and adjusting the price accordingly. Some high-quality logs may be suitable for use as veneer. Such logs generally command a premium price, and the differences between volumes determined by the different log rules become especially important.

Buyers of timber and logs often prefer the Doyle Rule, since we have seen that this rule underestimates the board footage (compared to the International 1/4-Inch Rule) for logs less than 30 inches in diameter. However, sawmillers justifiably argue that the milling costs for small-diameter logs are much higher, and thus they should have a reduced value. The Doyle Rule compensates the sawmiller by under scaling the smaller logs.

The important thing for you to remember is that different log rules exist, and the buying or selling of stumpage or logs should be based upon open agreement about which log rule will be used. Any of the three rules discussed here can serve as a useful method for scaling logs, as long as both the buyer and seller recognize and agree to its use. Prices can easily be adjusted to reflect the log rule being used.

Conclusion

When selling standing timber or logs, you should expect to receive the fair market price for your product, no more and no less. Bargains often come at considerable expense, including poor logging jobs, site degradation, or perhaps default on the part of the purchaser. Your Virginia Department of Forestry county forester, consulting foresters, and industrial foresters can provide you with assistance in this important process.

2025 420-085 (CNRE-201NP)

Eco-intelligent

Ecotones and Edges: Explaining abrupt changes in ecosystems

Saurab Babu

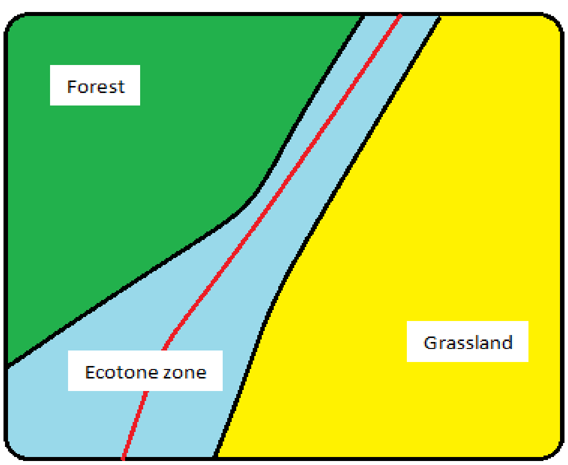
Have you ever wondered why floodplains host such a variety of life? Why fishes tend to congregate in estuaries for spawning? Why humans have thrived for so long along floodplains?

In nature ecosystems transition from one to another gradually or abruptly. These transition zones are extremely important from an ecological and economic point of view. They are very, very rich in biodiversity. Because of this richness and the complex conditions of this zone, it is vital for the economy of that region.

In this post, I'll take a look at the abrupt changes from one ecosystem to another. We'll also see what these abrupt changes cause and how that is important for life in that region. These regions have faced great damage due to human activities. Understanding their dynamics is important if we are to manage them better in the future.

What are ecotones?

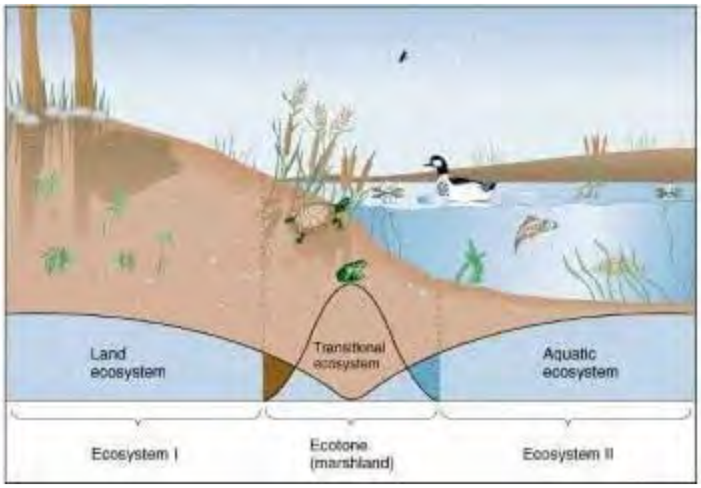
When an ecosystem (or community) changes abruptly from one to another, that zone is called an **ecotone**. This is a fundamental characteristic of landscapes that is often studied by landscape ecologists. This zone can traverse long stretches along two ecosystems and is a place where characteristics of *both ecosystems* can be seen. Therefore, it makes for a completely different habitat!



A forest-grassland ecotone.

Ecotones are created because of abrupt changes in environmental conditions.

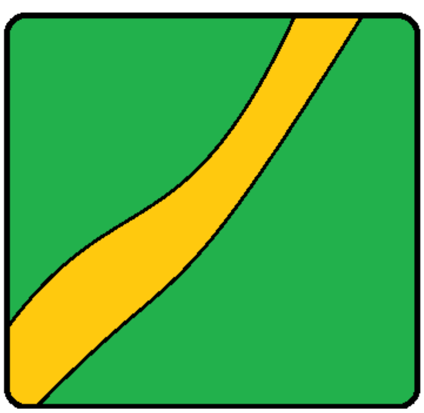
Plenty of examples exist in nature. The classic example of an ecotone is the **transition from a forest to a grassland ecosystem**. As the conditions of temperature and rainfall varies, you tend to see a slow change in the tree composition of the forest. Quite suddenly, the forest will give way to the open spaces of a grassland.



The floodplain ecotone, also called riparian zone.

Another example is that of a **floodplain; a shift from terrestrial to aquatic ecosystem**. The stretch of the bank where these two ecosystems meet forms one of the most important ecotones in nature.

You can have **ecotones within an ecosystem as well**. This is often seen in elephant habitats. When elephants move, they tend to break up the forest by trampling and create a grassland-type situation along their path. They use the same path over and over again (creating **elephant corridors**), eventually making sure there is no tree cover there. The end result will look something like this-



A representation of an elephant corridor.

Features of ecotones

Ecotones are of interest to ecologists because they are **not only a physical transition from one ecosystem to another, they also represent a transition in the living conditions**: both in habitats and niches. Along this ecotone, organisms from both communities face **increasing environmental stresses**.

For example, a deer (terrestrial animal) cannot live comfortably in an area that consists of wet marshlands (the ecotone between terrestrial and aquatic ecosystems). Similarly, the same deer will find it difficult to survive along the ecotone of a forest and a grassland because of lack of open spaces. It cannot keep a lookout for predators as effectively as it can in open grasslands.

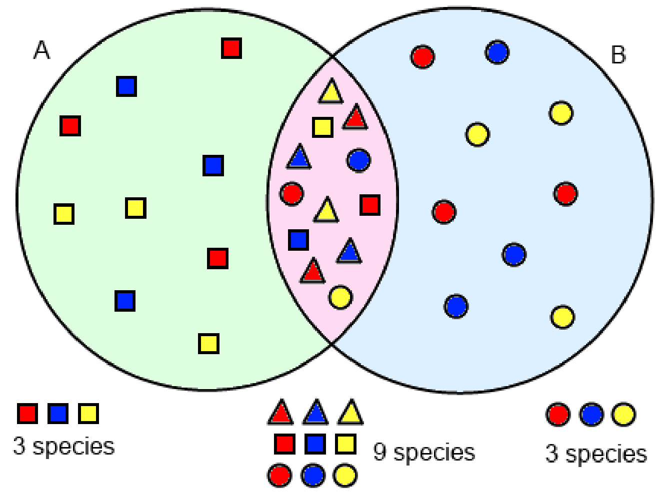
However, the zone also represent an **opportunity for other organisms**. This opportunity is as a result of different living conditions in close proximity to each other. Diversity leads to stability in nature; with greater vegetation complexity and landscape elements, many different organisms can survive in ecotones. For example, terrestrial organisms will come towards the river bank to drink water. Birds often thrive in these ecotones as they get fish for food.

Ecotones are harsh conditions for interior organisms but zones of opportunities for edge organisms.

Since the ecosystem characteristics are so unique in ecotones, we also find a **completely new array of species along this zone**. Taking the river-land example again, we will find many amphibians and reptiles living along this ecotone. These animals will not be found in the interior zones of either ecosystem.

What is the Edge Effect?

The greater number of landscape elements, vegetation complexity and mixed ecosystem characteristics result in greater density and biodiversity along the ecotones. This phenomenon is called the **edge effect**. For example, you will always find a greater number of bird species along the land-water ecotones. Similarly, the ecotones formed by seas and rivers (deltas or estuaries) have a greater number of fish species.



The new array of species living along edges are unique, and are called **edge species**. Amphibians are the classic edge species of floodplain ecotones. They are able to perform most of their daily activities along these edges.

There are some species that are "edge species" for only a short period of time. Seasonal edge species are quite common in nature. For example, there are some species of fishes that come from the sea to estuaries for spawning. Sea turtles are also unique organisms that come into beaches to lay eggs, and get back to their sea habitat when their young ones are ready. Some other species are found in both edge as well as interior habitats. The squirrel is an example. This change in spatial and temporal habits of organisms makes the definition of an edge species quite difficult.

Why are ecotones and edges important?

High biodiversity and highly sensitive zones

Ecotones and edges are unique because of the conditions they host. Their ability to support so many different organisms make them highly sensitive areas of biodiversity. These zones are harsh and sensitive; even small changes in their characteristics can be potentially disastrous for the organisms living there.

The human interest

Humans have affected ecotones and edges in their quest to modify these zones for their benefit. Edges also host advantageous conditions for humans. Along the river-land ecotone, the land is extremely fertile. It also has a ready water source in close proximity. These conditions are excellent for the development of agricultural land. **Why do you think great civilizations of the past were situated on floodplains?**

Our interference in interior ecosystems tend to create ecotones, in some cases. When a road is built through a forest, the path of the road represents a transition from the two forest ecosystems on either side. This artificial ecotone is also a tension zone for the interior organisms. For example, these "induced edges" play a detrimental role in seed dispersal of the nearby vegetation species.

Our interference has added another dimension to an already complicated condition in ecotones. Nowhere in nature has excessive human involvement been beneficial for life. This same is the case for ecotones. Understanding ecotone-dynamics help us understand how we are affecting them. This will help us plan our land-use better in the future.

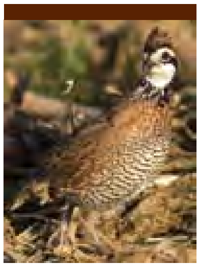
Conservation and restoration

Ecotones and edges are an active area of research for conservationists. If we can conserve and restore ecotones, we are effectively conserving a greater amount of biodiversity in nature. This was recognized when the Ramsar Convention was signed by 172 countries, vowing to protect the wetlands of the world. Wetlands form one of the greatest ecotone regions in the world. Today, so much biodiversity is being conserved and protected because of the decisions taken in that convention.

Ecotones and edges will remain a huge are of research for future ecologists, because its development, **maintenance and restoration** is extremely important to support the huge biodiversity it hosts, as well as the sustenance of many economic activities.

References:

Yahner, Richard. H. 1988. Changes in wildlife communities near edges. Conservation Biology 2(4): 333-339.



MISSISSIPPI STATE UNIVERSITY

Forest and Wildlife Research Center Note

Northern Bobwhite Management on Private Lands

Northern Bobwhite Management on Private Lands

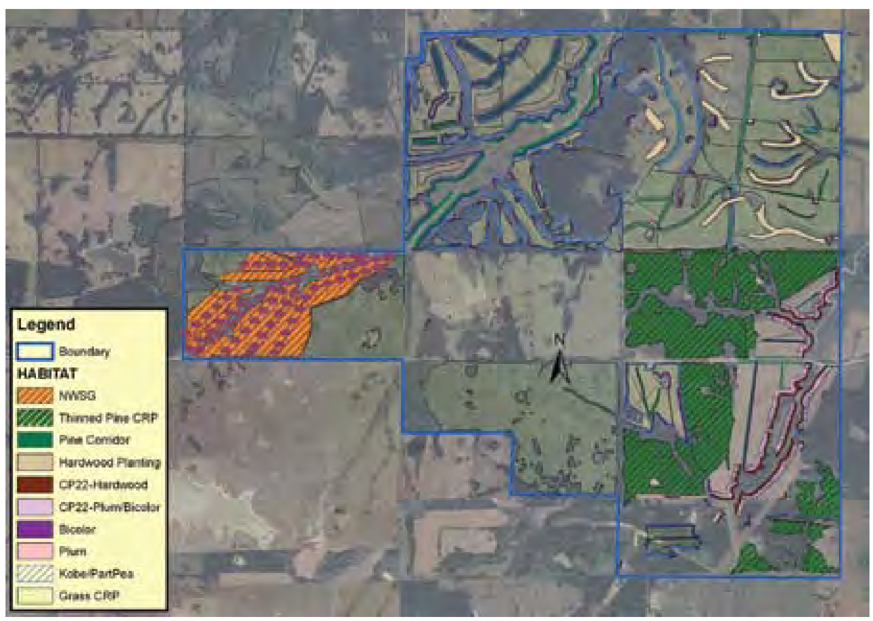
Historically, abundant bobwhite populations were an accidental byproduct of broadly applied land-use practices. In modern landscapes, the intentional creation and maintenance of early successional native plant communities is generally required to produce sustainable bobwhite populations. The magnitude of bobwhite population response to habitat management is scale-dependent. This means that the more intensive and extensive the habitat management, the greater the bird response. Expected population response to management is also influenced by landscape context. Throughout the South, there are numerous large (3,000-5,000 ac) public and private properties under varying degrees of active management. The degree of habitat management on these properties depends on landowner objectives and knowledge of conservation practices and opportunities. Management can vary in scale and intensity ranging from no management, to broadly applied but low-intensity conservation buffers, to comprehensive conservation involving a suite of conservation practices integrated throughout a production system.

Panola County, Mississippi Property Management

The Panola County tract is a 3,200 acre property located in the Loess hills of Northwest Mississippi.

Prior to 1997, the property was primarily dedicated to the production of row crops, forage crops, and forest products. Over the past decade the property has been systematically managed for wildlife habitat. Today, 75% of the property is actively managed for bobwhite with the goal of creating excellent recreational hunting opportunities.

The management objective was to provide 100% usable habitat for bobwhite within portions of the property allocated to wildlife habitat and increase the habitat quality in areas currently supporting birds.



Management practices included:

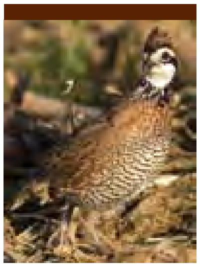
- Herbicidal eradication of fescue and bermudagrass;
- Conversion of row crop to native-warm season grasses (NWSG), forbs, and legumes;
- Management of existing grass CRP fields using strip-disking and prescribed fire;
- Rotational food plotting to provide additional food resources;
- Establishment of shrub thickets, wooded drains, and corridors for loafing, winter, and escape cover;
- Installment of grass/legume field borders on agricultural fields;
- Creation of transition zones between forest edges and early successional landscape;
- Heavy thinning, herbicidal midstory control, and prescribed burning of pine plantations.

Conservation planning was accomplished by a consultant wildlife biologist working with USDA-NRCS field office personnel. Conservation practices were implemented under the WHIP, CRP, (USDA-FSA), and U.S.F.W.S. Partners Programs.

NRCS

MISSISSIPPI WILDLIFE, FISHERIES, & PARKS

Mississippi State University™ College of Forest Resources Forest and Wildlife Research Center

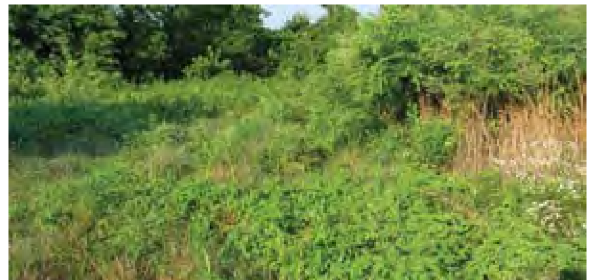


Panola County, Mississippi Property Management

Diverse CRP field managed with strip-disking and fire

Rotational food plots

Heavily thinned CRP pines management with fire



Shrub and legume plantings

Effects of Integrated Management

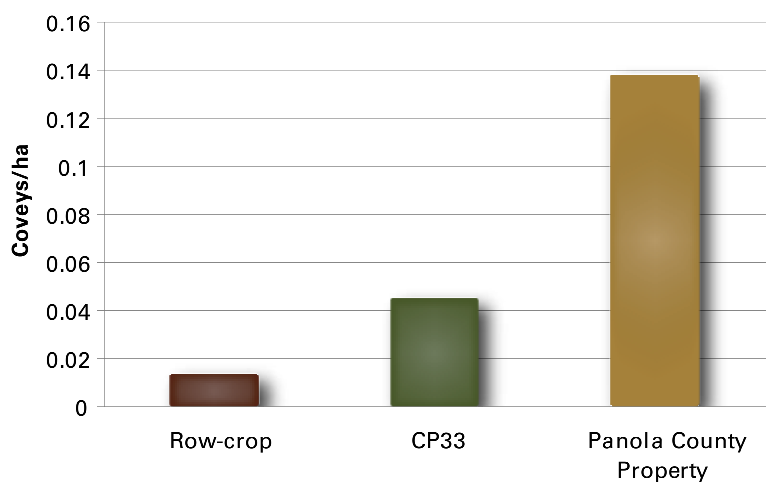
- In the absence of bobwhite management, 2007/2008 fall densities in the surrounding landscape of the Southeastern Coastal Plain averaged 1 covey/72 hectares or 1 bobwhite/6 hectares (assuming 12 bobwhites/covey).

- Addition of CRP CP33 field buffers to this landscape more than tripled fall density to an average of 1 covey/22 hectares or 1 bobwhite/1.8 hectares.

- The Panola County property, a landscape primarily dedicated to bobwhite management, produced farm-level fall densities of 1 covey/7 hectares or 1 bobwhite/0.6 hectares, bird densities that were almost 10 times greater than the surrounding landscape.

- Habitat management produced bobwhite populations sufficient to support excellent recreational hunting.

Northern Bobwhite Fall Covey Densities, 2007/2008



NRCS

Mississippi Wildlife, Fisheries, & Parks

Mississippi State University College of Forest Resources
Forest and Wildlife Research Center

Forestry Study Resources

Key Topic #5: Field Skills

17. Identify common Mississippi trees and plants by leaves, bark, branching patterns, buds, fruit, and other characteristics without the use of a key.
18. Use common forestry tools, such as:
    a. Biltmore Stick/Merritt Hypsometer
    b. D-tape
    c. Wedge Prism
    d. Tree Caliper
    e. Clinometer
    f. Increment Borer
    g. GPS
19. Calculate common forestry measurements, such as diameter at breast height (DBH), chain, cord, total tree height, merchantable height, board feet, log, and basal area.

Resource Title	Source	Located on Page
Forest Surveying Methods	*Nix, S. (2019, May 30). Forest Surveying Methods. ThoughtCo. https://www.thoughtco.com/forest-surveying-methods-distances-and-angles-1343236*	82
Mississippi Trees: American Elm, Baldcypress, Eastern Redbud, Longleaf Pine, Loblolly Pine, Southern Magnolia, Water Oak, White Oak	*Hodges, J.D., et al. (2016) Mississippi Forestry Commission. Mississippi Trees 2nd Edition. https://www.mfc.ms.gov/wp-content/uploads/2020/05/Mississippi-Trees-Book-Final-12.14.16-compressed.pdf*	86

Forest Surveying Methods

Using a compass and chain to reconstruct a forest boundary

Pamela Moore/E+/Getty Images

By Steve Nix
Updated on May 30, 2019

With the advent of public use of geographic positioning systems and the availability of aerial photographs (Google Earth) for free over the internet, forest surveyors now have extraordinary tools available to do make accurate surveys of forests. Still, along with these new tools, foresters also and reestablish lines which either disappear or become difficult to find as time passes.

A Fundamental Unit of Horizontal Measurement: The Chain

The fundamental unit of horizontal land measurement used by foresters and forest owners is the surveyors' or Gunter's chain (Buy from Ben Meadows) with a length of 66 feet. This metal "tape" chain is often scribed into 100 equal parts which are called "links."

The important thing about using the chain is that it is the preferred unit of measure on all public U.S. Government Land Survey maps (mostly west of the Mississippi River), which include millions of mapped acres charted in sections, townships and ranges. Foresters prefer using the same system and units of measure that were originally used to survey most forest boundaries on public land.

A simple calculation from chained dimensions to acres is the reason the chain was used in the initial public land survey and the reason it is still so popular today. Areas expressed in square chains can be easily converted to acres by dividing by 10 — ten square chains equals one acre! Even more attractive is that if a tract of land is a mile square or 80 chains on each side you have 640 acres or a "section" of land. That section can be quartered again and again to 160 acres and 40 acres.

One problem using the chain universally is that it was not used when land was measured and mapped in the original 13 American colonies. Metes and bounds (basically physical descriptions of trees, fences, and waterways) were used by colonial surveyors and adopted by owners before the public lands system was adopted. These have now been replaced by bearings and distances off permanent corners and monuments.

Measuring Horizontal Distance

There are two preferred ways foresters measure horizontal distance - either by pacing or by chaining. Pacing is a rudimentary technique that roughly

Pacing is used when a quick search for survey monuments/waypoints/points of interest might be useful but when you don't have the help or time to carry and drop a chain. Pacing is more accurate on moderate terrain where a natural step can be taken but can be used in most situations with practice and the use of topographic maps or aerial photo maps.

Foresters of average height and stride have a natural pace (two steps) of 12 to 13 per chain. To determine your natural two-step pace: pace the 66-foot distance enough times to determine your personal average two-step pace.

Chaining is a more exact measurement using two people with a 66-foot steel tape and a compass. Pins are used to accurately determine the count of chain length "drops" and the rear chainman uses the compass to determine the correct bearing. In rough or sloping terrain, a chain has to be held high off the ground to "level" position to increase accuracy.

Using a Compass to Determine Bearings and Angles

Compasses come in many variations but most are either handheld or mounted on a staff or tripod. A known starting point and a bearing are necessary for beginning any land survey and finding points or corners. Knowing local sources of magnetic interference on your compass and setting the correct magnetic declination is important.

The compass most used for forest surveying has a magnetized needle mounted on a pivot point and enclosed in a waterproof housing that has been graduated in degrees. The housing is attached to a sighting base with a mirrored sight. A hinged mirror lid allows you to look at the needle at the same moment you site your destination point.

The graduated degrees displayed on a compass are horizontal angles called bearings or azimuths and expressed in degrees (°). There are 360-degree marks (azimuths) inscribed on a survey compass face as well as bearing quadrants (NE, SE, SW, or NW) broken into 90-degree bearings. So, azimuths are expressed as one of 360 degrees while bearings are expressed magnetic north, not true north (the north pole). Magnetic north can change as much as +-20° in North America and can significantly affect compass accuracy if not corrected (especially in the North East and far West). This change from true north is called magnetic declination and the best survey compasses have an adjustment feature. These corrections can be found on isogonic charts provided by this U.S. Geological Survey download.

On reestablishing or retracing property lines, all angles should be recorded as the true bearing and not the declination corrected bearing. You need to set the declination value where the north end of the compass needle reads true north when the line of sight points in that direction. Most compasses have a graduated degree circle that can be turned counterclockwise for east declination and clockwise for west declination. Changing magnetic bearings to true bearings is slightly more complicated as declinations must be added in two quadrants and subtracted in the other two.

If there is no way to set your compass declination directly, you can mentally make an allowance in the field or record magnetic bearings and correct later in the office.

American elm

white elm, water elm, soft elm, Florida elm

***Ulmus americana* L.**

Family: Ulmaceae

Leaves:

Type: simple, alternate, deciduous
Size: 4.0” - 6.0” long; 2.0” - 3.0” wide
Margin: coarsely doubly serrate
Apex: acute - acuminate
Base: rounded-inequilateral
Shape: oblong-ovate
Color: dark green above; paler below
Surface: smooth to scabrous above; pubescent (rarely glabrous) below
Venation: pinnate

Twigs:

Size: slender
Color: current season red-brown to dark brown
Surface: smooth to sparsely pubescent; leaf scars semi-circular, raised; 3 bundle scars

Buds:

Size: terminal bud absent; laterals 0.25” long
Shape: ovoid, acute
Color: scales light brown with dark edges
Surface: glabrous

Fruit and Flowers:

Samara: winged; hairy on wing margin; flattened seed
Size: 0.5” long
Shape: oval to obovate; deep terminal notch
Color: green, occasionally orange-red
Flower: monoecious; perfect; apetalous; long-stalked, in clusters of 3-4; flower, 0.13” long; calyx, bell-shaped, reddish green; anthers, bright red; pistil, pale green, compressed

Bark: light to medium gray; broad flat ridges formed by deep diamond-shaped or elliptical fissures; when blazed exhibits alternating layers of buff colored and reddish brown tissue

Physical Attributes:

Form: single stem
Size: 120.0’, mature
Growth Rate: 50.0’ maximum @ 20 yrs
Life Span: (>100 yrs)
Tolerances:
Shade: medium
Drought: medium
Fire: low
Anaerobic: low
Propagation: seed (cold stratification required); bare root; container; cuttings
Other: resprout/coppice potential

Habitat and Ecology:

Site: flood plains, moist fertile slopes, margins of wet areas (streams, ponds and lakes), and drier uplands in association with other hardwood species
Soil Texture: fine - coarse
Soil pH: 5.5 - 8.0
Range: Montana; south through Wyoming, Nebraska, Kansas, Oklahoma and Texas; all states east; in Mississippi, throughout

Wildlife Value and Uses: although not considered a “preferred” browse, deer, rabbit, and hares will occasionally browse the leaves and twigs; seeds are eaten by a number of small birds; flowerbud, flower, and fruit are eaten by mice, squirrel, opossum, ruffed grouse, northern bobwhite, and Hungarian partridge; provides thermal cover and nesting sites for a variety of primary and secondary cavity nesters

Timber Value and Uses: wood is moderately heavy, hard, has interlocked grain, and is difficult to split; used principally for furniture, hardwood dimension, flooring, and construction; a small quantity used for pulp and paper manufacture

Landscaping Info: prized for its use as a street tree; fast growing, hardy, stress tolerant, and appreciated for its characteristic vaselike crown; flowers before leafout in the spring thus giving some of the earliest spring color

Other Facts: Dutch Elm disease and elm necrosis have reduced *Ulmus americana* from a species that once comprised a significant percentage of American forestland to one that is struggling for survival


Leaf

Fruit


Bark


Flower


Twig

baldcypress

southern-cypress, swamp-cypress, red-cypress, yellow-cypress, white-cypress, tidewater red-cypress

***Taxodium distichum* (L.) Rich.**
Family: Taxodiaceae

Needles:

Type: spiral, 2-ranked in one plane, deciduous along with supporting twigs
Size: 0.5” - 0.75”
Color: yellow-green
Characteristics: feathery; linear; flat

Twigs:

Size: slender
Color: light green-tan, becoming reddish brown
Surface: somewhat rough; fibrous

Buds:

Size: small
Shape: globular
Color: reddish brown
Surface: several overlapping pointed scales

Cones:

Pollen Cones: monoecious; produced in elongated, drooping catkins, 3.0” - 5.0” long
Ovulate Cones: monoecious; composed of several green, overlapping scales, fused at base; solitary or in clusters (2-3) near ends of previous year’s twigs; 0.25” long
Mature Cones:
Size: 0.75” - 1.0” dia.
Shape: nearly globular
Characteristics: yellow-brown; leathery; disintegrates at maturity; scales club-shaped
Seeds: 3-winged; irregularly 3-angled

Bark: ashy gray to reddish brown; coarsely fissured; scaly plates; peels into fibrous strips

Physical Attributes:

Form: single stem
Size:130.0’, mature
Growth Rate: 45.0’ maximum @ 20 yrs
Life Span: (>100 yrs)
Tolerances:
Shade: medium
Drought: low
Fire: low
Anaerobic: high
Propagation: seed (cold stratification required); bare root; container
Other: resprout/coppice potential

Habitat and Ecology:

Site: typically found in permanent swamps in pure stands or with water tupelo; on slightly higher sites found with bottomland hardwoods; best site is deep, moist, sandy loam --- but cannot compete with hardwoods on these “best” sites
Soil Texture: fine - coarse
Soil pH: 4.6 - 6.0
Range: Atlantic and Gulf Coastal Plains, lower Mississippi River Valley and bottom lands of adjacent drainages; in Mississippi, scattered throughout

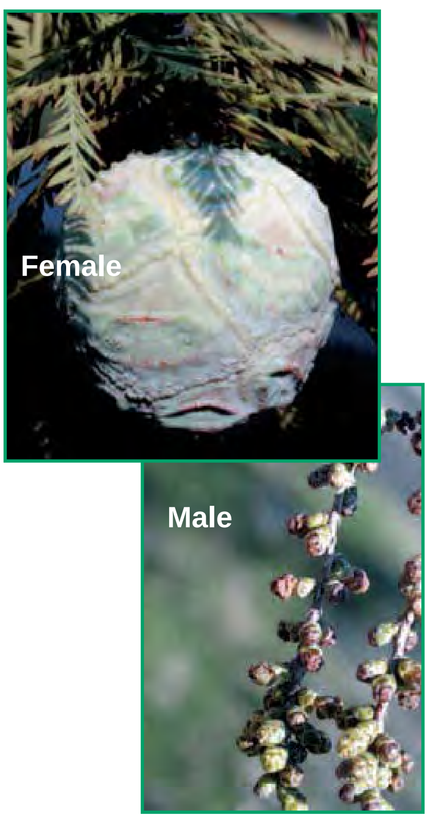
Wildlife Value and Uses: seeds eaten by wild turkey, wood ducks, evening grosbeak, squirrels, waterfowl and wading birds; cypress domes provide unique watering places for a variety of birds and mammals and breeding sites for frogs, toads, salamanders and other reptiles; tops provide nesting sites for bald eagles, ospreys, herons and egrets; yellow-throated warblers forage in the Spanish moss often found hanging on the branches

Timber Value and Uses: heartwood is second only to redwood in resistance to decay; has always been in demand for construction timbers, docks, exterior siding, and any similar use where its many unique qualities are an asset; potential for rehabilitating margins of surface-mined lakes; environmentally, riverine swamps of bald cypress reduce damage from floods and act as sediment and pollutant traps

Landscaping Info: stately and formal year-round appearance; strongly pyramidal; rapid growth and establishment; wet-site-loving and dry-site-adaptable; ultra-fine-textured foliage (resulting in dappled shade in youth); exfoliating strips of subtly ornamental cinnamon bark; rich cinnamon-brown autumn leaf color; leaf cleanup in autumn minimal or not needed; bark and wood is processed from natural stands in the southeastern U.S. as a slow-decaying, orange-brown mulch

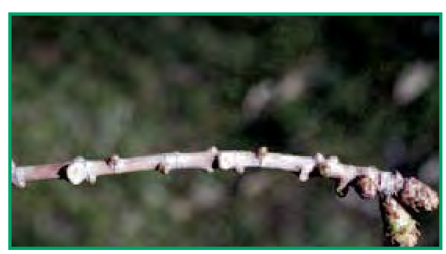
Other Facts: resin from cones used locally as an analgesic of skin lesions; knees are collected and used to create tourist appeal crafts; one of the most prized and valuable trees in the original forests of the South; many averaged over 500 yrs old, and often 6 to 8 feet dia.


Needles



Cones

Bark


Twig

eastern redcedar

cedar tree, juniper, savin, evergreen, cedar apple, Virginia red cedar

***Juniperus virginiana* L.**

Family: Cupressaceae

Leaves:

Type: evergreen; 2 forms;
1) juvenile opposite in pairs, or ternate;
2) mature 4-ranked
Size: juvenile 0.25” long; mature 0.06” long
Color: juvenile light green; mature dark green with glandular dots (both turn brown end of 2nd winter)
Characteristics: juvenile awl-shaped, sharp pointed, spiny to touch; mature shalelike, usually appressed

Twigs:

Size: slender; terete or angled
Color: dark green; then reddish
Surface: covered by compact scale-like leaves

Buds:

Size: minute
Shape: (no data)
Color: (no data)
Surface: hidden by leaves

Cones:

Pollen Cones: dioecious; minute; 0.13” long; 10-12 yellow-brown pollen sacs
Ovulate Cones: dioecious; minute; globular; several purplish, fleshy scales, each with 1-2 basal ovules
Mature Cones:
Size: 0.25” dia.
Shape: ovoid
Characteristics: greenish blue with glaucous bloom (mature one season); fleshy, berrylike
Seed: wingless; ovoid; sharp-pointed; 0.17” long

Bark: thin; reddish brown; fibrous; long, narrow strips; fluted trunks; buttressed at base

Physical Attributes:

Form: single stem
Size: 50.0’, mature
Growth Rate: 25.0’ maximum @ 20 yrs
Life Span: (>50 yrs)
Tolerances:
Shade: medium
Drought: high
Fire: low
Anaerobic: low
Propagation: seed (cold stratification required); bare root; container; cuttings
Other: resprout/coppice potential

Habitat and Ecology:

Site: found on wide variety of soils; best growth on light, calcareous loams; most abundant, however, on dry, shallow, rocky soils --- many times where nothing else will grow
Soil Texture: fine - coarse
Soil pH: 4.7 - 8.0
Range: eastern United States and southern Ontario; in Mississippi, throughout

Wildlife Value and Uses: twigs and foliage eaten extensively by hoofed browsers; ovulate cones an important part of the diet of numerous birds and mammals, both large and small; important nesting cover for chipping sparrows, robins, song sparrows, and mockingbirds; roosting cover for juncos, myrtle warblers, sparrows of various kinds, and other birds; especially valuable as dense winter protective cover; widely used in shelterbelts and wildlife plantings

Timber Value and Uses: close-grained, aromatic, and durable wood used for furniture, interior paneling, novelties, and fence posts; fruits and young branches contain aromatic oil used in medicines

Landscaping Info: often used as ornamentals for their evergreen foliage; generally propagated by cuttings; seedlings ordinarily used as stock for grafting ornamental juniper clones; especially well adapted to dry areas

Other Facts: symbolizes the tree of life for numerous Native American tribes; used as incense in rituals and burned in sweat lodges and in purification rites; used teas, ointments, and liniments made from the leaves, cones, and roots and combinations of them to treat arthritis and rheumatism, coughing; colds, fevers, tonsillitis, and pneumonia; also used as a sedative for hyperactivity, and to speed delivery during childbirth; wood utilized for lance shafts, bows, and other items; red cedar flutes were highly regarded by the Cheyenne; cedar boughs were used for bedding; Menomini wove mats of cedar bark used for roofing temporary structures, for partitions, floor mats and wrappings; wood used in the construction of lodges, totems, and war canoes by Native Americans of the northwest coast

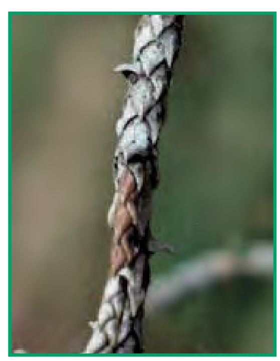
Leaf

Fruit

The young leafy twigs were officially listed in the U.S. Pharmacopoeia from 1820 to 1894 as a diuretic (Kindscher 1992). The distilled oil has been officially listed as a reagent in the U.S. Pharmacopoeia since 1916

Bark

Tree



Twig

longleaf pine

longstraw pine, southern yellow pine, Georgia pine

***Pinus palustris* Miller**

Family: Pinaceae

Needles:

Type: 3 per fascicle; evergreen; persistent for 2 seasons
Size: 10.0" - 18.0" long; fascicle sheath 0.5" - 1.0" long
Color: dark green
Characteristics: coarse; flexible; drooping; densely crowded

Twigs:

Size: very stout (0.5"> dia.)
Color: orange-brown
Characteristics: rough; scaly

Buds:

Size: large, conspicuous
Color: silvery gray base; silvery white fringed scales
Characteristics: outward curled scales at base; fuzzy/hairy podlike center

Cones:

Pollen Cones: dark purple-blue; 1.0" - 1.5" long; large clusters at base of terminal buds
Ovulate Cones: rose-purple; in pairs or clusters (3-4)
Mature Cones:
Size: 6.0" - 10.0" long
Shape: narrowly conical-cylindrical
Characteristics: raised scales; keeled on ends; small reflexed prickle that curves toward the base of the scale
Seed: winged; 0.5" long; thin pale shell, mottled with dark blotches; wing 0.5" long, striped, oblique at the ends; widest at middle

Bark: gray brown; scaly young; becomes broken into flat, scaly, thick reddish brown plates with age

Physical Attributes:

Form: single stem
Size: 120.0', mature
Growth Rate: 40.0' maximum @20 yrs
Life Span: (>50 yrs)
Tolerances:
Shade: low
Drought: low
Fire: medium
Anaerobic: low
Propagation: seed (cold stratification required); bare root; container
Other: no resprout/coppice potential

Habitat and Ecology:

Site: occurs in a wide variety of upland and flatwood sites; common on sandy, infertile, well-drained soils, mostly below 660 feet elevation
Soil Texture: medium - coarse
Soil pH: 6.0 - 7.0
Range: Atlantic and Gulf Coastal Plains from southeastern Virginia to central Florida; west to eastern Texas; not found in the Mississippi River Valley; to 900' in Alabama; in Mississippi, reported in 16 counties by the NRCS Plants Database --- primarily in the southeastern quarter of the State

Wildlife Value and Uses: large seeds eaten by birds and small mammals; germinating seeds eaten by ants; roots of seedlings eaten by razorback hogs; excellent habitat for bobwhite quail, white-tailed deer, wild turkey, and fox squirrel; old-growth stands provide nesting habitat for the red-cockaded woodpecker

Timber Value and Uses: wood is often clear, straight, and with few defects; a significant portion of the annual cut is used in the manufacture of kraft paper and paperboard; resins are fractionally distilled and used in the production of many diversified products such as paints, varnishes, pharmaceuticals, lubricants, and cloth-printing inks

Landscaping Info: no cultivars are currently recommended; seeds and seedlings commercially available from woody plant seed companies; needles are used for mulch

Other Facts: seedlings stemless after one growing season (grass stage) which persists from 2 to many years; during this stage, the seedling develops an extensive root system, and the root collar increases in diameter; as root collar diameter approaches 1.0" diameter, height growth begins

reported that in colonial times some of the choicest stands of longleaf pine were set aside for exclusive use by the British navy because it was ideal for the construction of masts and spars on England's sailing ships

Needles

Young Cones

Mature Cone

Bark

Terminal Bud

loblolly pine

Arkansas pine, North Carolina pine, oldfield pine

***Pinus taeda* L.**

Family: Pinaceae

Needles:

Type: needles; 3 per fascicle; evergreen; persistent for 3 seasons
Size: needles 6.0” - 9.0”; fascicle sheaths 0.25” - 0.5” long
Color: dark green; new growth lighter
Characteristics: stout; stiff; straight; lustrous new growth; dull older growth

Twigs:

Size: moderately stout
Color: greenish brown; then light brown
Surface: rough, flaky on young branches; smooth on older branches

Buds:

Size: 0.75” - 1.0” long
Shape: scales wedge-shaped
Color: reddish brown scales
Surface: scales free; commonly reflexed at tips

Cones:

Pollen Cones: yellow-green; 1.0” - 1.5” long; in large compact clusters at base of terminal buds
Ovulate Cones: pale green; in pairs of 3 to 4 per cluster; slightly stalked
Mature Cones:
Size: cone 3.0” - 6.0” long
Shape: ovoid-conical
Characteristics: reddish brown; sessile; flattened; wrinkled, armed on the back with a short, stout, sharp spine; scales thin, exposed portions of closed cone tawny
Seed: winged; 0.25” long; dark brown, black mottles; wings yellowish brown to gray-black, 0.75” long; widest above middle

Bark: dark gray to nearly black on young trees; older trees dark reddish brown, large flat rectangular plates

Physical Attributes:

Form: single stem
Size: 100.0’, mature
Growth Rate: 50.0’ maximum @ 20 yrs
Life Span: (>50 yrs)
Tolerances:
Shade:low
Drought: low
Fire: high
Anaerobic: low to medium
Propagation: seed (cold stratification required); bare root; container
Other: no resprout/coppice potential except for young seedlings

Habitat and Ecology:

Site: widely scattered on a variety of sites in the coastal plains and lower Piedmont Plateau in pure or mixed stands; aggressive on fallow fields or cutover sites
Soil Texture: fine - coarse
Soil pH: 4.5 - 7.0
Range: southern New Jersey; south to central Florida; west to southeastern Texas and southern Oklahoma; in Mississippi throughout with the exception of the Mississippi River Delta counties

Wildlife Value and Uses: primary game species that inhabit pine and pine-hardwood forests include white-tailed deer, gray and fox squirrel, bobwhite quail, wild turkey, mourning dove, and rabbit; some species utilize the habitat through all stages of stand development; others attracted for a short time during a particular stage of development; chief habitat for the pine warbler, brown-headed nuthatch, and Bachman's warbler; old-growth stands important to the existence of the red-cockaded woodpecker; important nesting site for ospreys and the bald eagle

Timber Value and Uses: most commercially important forest species in the southern United States; makes up over one-half of the standing pine volume; used for lumber, construction timbers, pulp, and plywood; considered inferior in quality to longleaf or shortleaf but used similarly

Landscaping Info: often used in urban forestry as shade trees, and for wind and noise barriers throughout the South; used extensively for soil stabilization; provides rapid growth and site occupancy

Other Facts: biomass for energy currently obtained from precommercial thinnings and logging residue; utilization of these sources will undoubtedly increase, and loblolly pine energy plantations may become a reality

Needles

Mature Cone

Bark

Young Cones

Twig/ fascicles

southern magnolia

evergreen magnolia, bull-bay, big-laurel

***Magnolia grandiflora* L.**

Family: Magnoliaceae

Leaves:

Type: simple; alternate, persistent
Size: 5.0” - 8.0” long; 2.0” - 3.0” wide
Margin: entire
Apex: bluntly pointed; rarely sharp pointed
Base: wedge-shaped
Shape: oval, ovate, oblong
Color: dark green above; rusty red below
Surface: shiny above; pubescent (woolly hairs) below
Venation: pinnate

Twigs:

Size: moderately stout
Color: rusty red
Surface: tomentose (woolly hairs); leaf scars shield-shaped; bundle scars in a marginal row; stipule scars encircle twig above leaf scar

Buds:

Size: terminal 1.0” - 1.5” long; laterals smaller
Shape: ovoid
Color: pale or rusty
Surface: pubescent (woolly)

Fruit and Flowers:

Aggregate of follicles: hairy; seed, suspended from open pods by slender elastic thread
Size: 3.0” - 4.0” long, 1.5” - 2.0” dia.; seed 0.5” long
Shape: ovoid to cylindrical; seed slightly flattened,
Color: orange-red; seed, red
Flower: monoecious; perfect; on stout, hairy stalks, 6.0” - 8.0” dia.; petals (6,9, or 12), white, 3.0” - 4.0” long; showy; very fragrant

Bark: light brown or gray-brown; smooth, then lightly furrowed; scaly flat plates

Physical Attributes:

Form: single stem
Size: 100.0’, mature
Growth Rate: 40.0’ maximum @ 20 yrs
Life Span: (>100 yrs)
Tolerances:
Shade: high
Drought: low
Fire: low
Anaerobic: low

Propagation: seed (cold stratification required); bare root; container (air-layering, stem cuttings, and grafts have all been used to propagate the species for ornamental plantings)
Other: resprout/coppice potential

Habitat and Ecology:

Site: rich bottom lands or gentle protected slopes
Soil Texture: fine - medium
Soil pH: 4.5 - 6.5
Range: eastern North Carolina; south to central Florida; then west through roughly the southern half of the Gulf coastal states into southeast Texas; most prevalent in Louisiana, Mississippi, and Texas; in Mississippi, throughout the southern half of the State, along with Marshall and Lafayette counties in the northcentral part of the State, and Washington country in the Mississippi River Delta

Wildlife Value and Uses: seeds are eaten by squirrel, opossum, quail, and turkey

Timber Value and Uses: cut in limited quantities for timber; furniture, paneling, veneer, cabinet work

Landscaping Info: one of the South’s finest semi-evergreens; valuable and extensively planted ornamental; good in urban areas --- resistant to damage by sulfur dioxide

Other Facts: leaves, fruits, bark and wood yield a variety of extracts with potential applications as pharmaceuticals

Leaf

Fruit

Bark

Flower

Twig

water oak

possum oak, spotted oak, pin oak, red oak

***Quercus nigra* L.**

Family: Fagaceae

Leaves:

Type: simple, alternate, deciduous or tardily deciduous
Size: 2.0”- 4.0” long; 1.0”- 2.0” wide
Margin: entire; lobed (2-3) or; variously lobed (usually applicable only to sprouts and juvenile plants)
Apex: acute to broadly obtuse
Base: wedge-shaped
Shape: spatulate, to obovate or oblong
Color: dull green above; pale green below
Surface: glabrous above; pubescent tufts below
Venation: pinnate

Twigs:

Size: slender
Color: dark red-brown to brown
Surface: smooth, glabrous

Buds:

Size: 0.12” - 0.26” long
Shape: ovoid, pointed apex
Color: chestnut brown
Surface: pubescent scales

Fruit and Flowers:

Nut: acorn, biennial; cup shallow, pubescent both surfaces; covers up to 25% of nut
Size: 0.38” - 0.63”
Shape: nearly round
Color: nearly black; faint stripes
Flower: monoecious; unisexual; staminate, stalked, hairy, yellow, catkins, 2.0” - 3.0” long; pistillate, mostly solitary, on short, hairy stalks

Bark: light brown to black; furrows; relatively smooth when young; wide scaly ridges with age

Physical Attributes:

Form: single stem
Size: 90.0’, mature
Growth Rate: 30.0’ maximum @ 20 yrs
Life Span: (>50 yrs)
Tolerances:
Shade: low
Drought: low
Fire: low
Anaerobic: medium
Propagation: seed (cold stratification required); bare root; container
Other: resprout/coppice potential

Habitat and Ecology:

Site: wet lowland to moist upland soils; can occur on most upland sites, and on deep sand deposits in bottomlands
Soil Texture: fine - medium
Soil pH: 4.8 - 5.8
Range: New Jersey; south to Florida; west to Texas; north to Missouri; east to Virginia; in Mississippi, ubiquitous

Wildlife Value and Uses: cover, food, and habitat for wildlife; acorns eaten by squirrel, chipmunks, waterfowl, blue jays, wild turkey, and northern bobwhite; cached by blue jays and squirrels in the fall; home for cavity nesters; deer browse but palatability is low

Timber Value and Uses: rough construction lumber; moderate quality lumber on good sites but prone to excessive splitting; veneer used as plywood for fruit and vegetable containers; on poor sites prone to knots, mineral stains, and insect damage

Landscaping Info: rapid growth; dense foliage, fairly thick leaves and long leaf retention; fairly broad site adaptability; good shade tree choice in the South

Other Facts: one of the largest known specimens is located in Jones County, Mississippi

Leaf

Fruit

Bark

Twig

white oak

eastern white oak, stave oak, forked-leaf white oak

***Quercus alba* L.**

Family: Fagaceae

Leaves:

Type: simple, alternate, deciduous
Size: 5.0"- 9.0" long; 2.0" - 4.0" wide
Margin: deeply lobed (7-9); oblique, rounded sinuses nearly to midrib
Apex: rounded; usually 3-lobed
Base: cuneate
Shape: obovate/oblong
Color: bright green above; light green to whitish below
Surface: smooth above and below
Venation: pinnate

Twigs:

Size: slender
Color: red-brown to somewhat gray
Surface: initially pubescent; then glabrous

Buds:

Size: 0.12" - 0.19" long
Shape: ovoid, apex obtuse
Color: dark reddish brown
Surface: glabrous

Fruit and Flowers:

Nut: acorn, annual; cup bowl-shaped, thick warty scales, covers 25% of nut
Size: 0.5" - 1.0" long
Shape: oval
Color: shiny brown
Flower: monoecious; unisexual; staminate, loose, pendulous, yellow, catkins, 3.0" long; pistillate flowers, bright red, short-stalked, solitary

Bark: whitish or ashy gray; varies from scaly to irregularly platy or blocky; smooth patches on older trees not uncommon

Physical Attributes:

Form: single stem
Size: 60.0' -100.0', mature
Growth Rate: 20.0' maximum @ 20 yrs
Life Span: (>100 yrs)
Tolerances:
Shade: medium
Drought: medium
Fire: medium
Anaerobic: low
Propagation: seed (cold stratification not required); bare root; container
Other: resprout/coppice potential

Habitat and Ecology:

Site: found on many soil types, best on coarse, deep, moist, well-drained soils, with medium fertility, and slightly acid soil
Soil Texture: medium - coarse
Soil pH: 4.5 - 6.8
Range: Maine to Minnesota; south to Florida; west to Texas; in Mississippi, throughout the State, the primary exception being the Mississippi River Delta counties, and a band across the north-central part of the State associated with Blackland Prairie soils

Wildlife Value and Uses: acorns eaten by squirrel, blue jays, crows, red-headed woodpeckers, deer, turkey, quail, mice, chipmunks, ducks and raccoon; browse palatability medium

Timber Value and Uses: the most important timber oak; commercially important throughout much of the South and East; strong and durable wood for furniture, veneer, paneling, and flooring, staves for barrels, lumber, and interior woodwork; also used for specialty items such as wine and whiskey barrels; fuelwood product value is high

Landscaping Info: excellent tree because of its broad round crown, dense foliage, and purplish red to violet-purple fall color; difficult to transplant; growth slow; existing trees very sensitive to disturbances in root zones caused by grading, soil compaction, or changes in drainage patterns - if severe can lead to mortality

Other Facts: used medicinally by Native Americans

Leaf

Bark

Twig

Fruit

Sprouts