Forestry – “In wilderness is the preservation of the world” Henry David Thoreau

**Forests**

A forest is a living, complex community comprised of trees, associated plants, and animals. Trees, the distinguishing feature of a forest, are second only to grasses as the most common and widely distributed plants on earth. The plants and animals of the forest community grow, age, and die. Nutrients from their bodies are released and recycled by decomposers. From the soil, the trees obtain nutrients and moisture. Using sunlight, the trees make food, grow, and produce the wood and numerous other products used by man.

**Forests – Past and Present**

Forests have and do play important social and economic roles in the United States. Trees provided the native Indians and early settlers with shelter, fuel, medicines, shade, tools, protection and other needs. The Indians and settlers used fire to clear sections of the forest for camps, settlements, and land to grow crops. Today our country is dependent on the over 10,000 products and the services provided by our forests.

The first white men to utilize the North American forest were the Vikings. History states that the Vikings sailed to the northern United States in search of timber for use in their settlements in Greenland. The Vikings returned and established a logging camp, which is thought to have been in present day Labrador.

Possibly the first white men to see the original, untouched southern forests were John Cabot and his son in 1498. The men had been sent on an exploration trip by King Henry VII.

After the adventurers and explorers, settlers began moving southward. The rivers, Indian trails and tributaries were used as the highways, in the absence of roads. With the arrival of settlers, timber became important. The trees were used to make rafts and boats, cabins, sheds and fences for livestock, and blockhouses and stockades for protection. The forests supplied much of their food, clothing, and medicines, as well as fuel to keep warm and cook. As dependent on the forests as the settlers were, they also saw them as a hindrance. Settlers of that time found the forest a problem for both crop production and defense. Forests were cleared to grow crops, to provide grass for livestock, to eliminate hiding places for unfriendly Indians, and to discourage wild animals from the area of the settlement.

Ships began making regular trips to the new land. The ships needed naval stores – tar, pitch, turpentine, and rosin which were used for repairing, waterproofing, and painting ships. These products were also used for manufacturing soaps and candles, and treating cuts and bruises.

The naval stores came from the southern pine forests. They were one of North Carolina’s most valuable economic products for 200 years, and for much of that time, North Carolina was the world leader in production of naval stores. Ships, particularly the British and French navies needed tall, straight trees for the masts of their ships. The southern forests also provided these products.
With the increasing travel, settlements and cities along the southern coast began growing fast. More timber was needed to build and supply these cities. A great demand for wood and its products developed throughout the coastal south and along the major river highways.

The southern forests seemed so vast that it was believed the wood supply would never be exhausted. The need for wise use and management of the forests was hard to understand at that time and there seemed to be no economic justification for sparing them.

The development of the English colonies in the seventeenth century marked the beginning of commercial use of our forest resources. The first sawmill in the United States is thought to have been in Jamestown, Virginia, in 1625, and sawmills soon became a part of every colony. They supplied the local need for lumber and produced a surplus for export throughout the world. Industrial development in the South was influenced by the invention of the first steam-powered circular sawmill in 1803. By the 1890’s, timber supplies in some areas of the country were becoming depleted, and the South was called upon to supply even larger amounts of wood. In 1895, lumbering had become a major industry in the South. By 1909, lumber production reached its peak, when 50,000 mills cut an estimated 46 billion board feet of lumber and employed 500,000 men. In 1919, the South cut half of all the lumber used in the United States.

Little thought was given to the future, and the forests were not cut wisely. Clear cutting of the forest was common practice. The cleared land became farms and grazing lands, but it soon became barren because of erosion or nutrient depletion or did not grow vegetation or crops well. The settlers did not realize the land was best suited to growing the forests that had once occupied it.

There are 19.3 million acres of forested land in North Carolina. In the United States, only three other states (Georgia, Alabama, and Oregon) have more forested land. Almost 97% (18.7 million acres) of North Carolina’s forested land is used for the production of timber. Upon consideration of these numbers, it is not surprising that forestry is the second largest industry in North Carolina today.

Most of the forests in the state (77%) are owned by private citizens who own less than one hundred acres. Forest industries within the state own approximately 13% of the forested land. Local governments, the state, and the federal government own the remaining 10% of North Carolina’s forested land. Almost two-thirds of the land area of North Carolina is classified as commercial forest land, or land that is capable of growing forest trees.

North Carolina’s forest trees, on most of the land, have been cut at least once for use as timber or for the production of other wood products. The state has virtually no forests that have not previously been harvested or significantly disturbed by man at some point. Only a few old growth stands remain in mountain coves that were inaccessible or too difficult to log. Once timber has been harvested, subsequent harvests become increasingly smaller and of lower quality unless the regrowth of the forest is carefully managed.
The History of Forestry

The federal government first appropriated funds for the acquisition of timberland in 1799. These funds were used to buy reserves of live oaks in coastal South Carolina and Georgia to supply the growing nation with reserves of ship timbers and masts. Year’s later additional public lands in Florida, Alabama, and Louisiana were purchased for their stands of cedars and live oaks, and funding was provided for experiments in planting and cultivating live oaks. This was the beginning of federal forest research in the United States.

In the years that followed, the exploitation of the nation’s forest resources increased and was encouraged by the federal government’s policies.

By 1873, scientific concern over the destruction was growing. A report on “The Duty of Governments in the Preservation of Forests” was presented by Dr. Franklin Hough. President Grant encouraged Congress to take action in 1874, but action was not taken until 1876, when the first appropriation for forestry was made. An agent in the Department of Agriculture was to conduct forestry investigations including the first survey of the nation’s timber resources. Dr. Hough was placed in the position and conducted the research. In 1881, a Division of Forestry was created in the Department of Agriculture.

Forestry, as a discipline, in the United States began at the Biltmore Estate. Gifford Pinchot was hired to manage the forest on the 7,000 acre estate. For three years, he worked to show that treating forests as sustainable (replaceable) could be profitable. Pinchot’s goal was a revolutionary idea. He wanted to change the American exploitation and reckless use of its forest resources. Pinchot believed America’s forests were renewable, despite the abuse of poor logging and planting practices, and that they could produce a sustainable supply of timber.

When Pinchot left Biltmore in 1895, George Vanderbilt hired Carl Schenck, a German, because America had no other trained forester at that time. Schenck tried to teach his apprentices which trees should be cut and how many seedlings should be planted. He had to order seedlings from Germany, because there were no forest nurseries in America. Schenck realized that a school to train foresters was needed in America.

In 1898, this became a reality when Dr. Schenck founded the first American school of forestry, the Biltmore Forest School, and brought his thorough training in scientific silviculture to the United States. That same year, the New York College of Forestry at Cornell University also opened to interested students. At these schools, students learned silviculture, dendrology, lumbering and technology, classification, zoology, law, economics, and more. They learned to cruise timber, fell trees, transplant seedlings, and saw logs.

In 1901, the Division of Forestry of the U. S. Government was known as the Bureau of Forestry, and in 1905, it became the Forest Service. Gifford Pinchot became the first chief of the Forest Service. The American Forestry Association’s efforts led to the first law establishing forest reserves for the public domain enacted by Congress in 1891. These reserves became the national forests in 1907.
Recognized as the “Cradle of Forestry,” the Biltmore Forest School closed in 1913, but it was a major part of the beginning of forestry in this country. It had a tremendous impact on the new practice of American forest management. Half of its 300 graduates went on to practice forestry in the beginning U.S. Forest Service, state forestry programs, or timber companies; and they played important roles in the following decades. Pinchot and Schenck began it all with their idea that forests were renewable, that a sustainable supply of timber could be produced, and that forests could be profitable for landowners, if managed well.

State forestry began in 1885, when California established the first forest agency in the United States. That same year, Colorado, Ohio, and New York also began agencies. North Carolina, Virginia, Louisiana, and Texas were the only southern states to have forestry agencies prior to 1921.

State forestry agencies’ progress has been aided by cooperation with the federal government. Laws impacting state forestry include the following.
- **The Weeks Law** – 1911 – financial aid to states in forest fire protection
- **The Clarke-McNary Law** – 1924 (amended 1949) – additional help for fire protection, production and distribution of nursery stock, and assistance in farm forestry
- **The McSweeney-McNary Law** – 1928 – a national program of forest research and a survey of forest resources
- **Emergency Conservation Work Program**, later known as the C.C.C. or Civilian Conservation Corps – 1933 – provided aid in reforestation, road construction, and fire control, and other activities
- **The Norris-Doxey Cooperative Farm Forestry Act** – 1937 (superseded by the Cooperative Farm Management Act of 1950) – federal financial assistance to provide technical services to landowners in the management, harvesting, and marketing of forests
- **The Forest Incentive Program** – 1973 – share the cost of tree planting and forest management with small forest landowners
- **Water Pollution Control Act** – 1972 - EPA provide information to control pollution from silviculture practices
- **The National Forest Management Act** – 1976 – required the use of multiple-use management – an ecosystem approach

Forestry services are provided by many other agencies. The state extension services, through forestry specialists, work with forest landowners, public agencies, and private industry to advance forestry. The Natural Resource Conservation Service (NRCS) works with Soil and Water Conservation Districts providing technical services for planning an integrated soil, water, and forest conservation program for landowners, and coordinates with other organizations to help landowners make sound decisions concerning the wise use and treatment of forest resources. The Federal Land Banks provide long-term loans to forest landowners. The U.S. Department of Agriculture’s Farm Services Agency, known as FSA, provides cost-sharing programs for forestry practices. The Tennessee Valley Authority is responsible for 22.2 million acres of forestland. The Bureau of Land
Management has major land holdings in the Northwest and Alaska and carries out intensive forest management. America has come a long way from widespread exploitation of its forest resources to conservation, management, and wise use of those resources. Today, the U.S. Forest Service manages forests on public lands and our national forests. The U.S. Forest Service has a double mandate: to maintain our forest resources and to provide an ongoing supply of timber.

In 1992, 47 million acres of forestland, 6% of all U.S. forestland, was reserved from commercial timber harvest in wilderness, parks, and other classifications. 737 million acres of land were classed as forestland in 1992. This figure represents 33% of the total land area and amounts to about two thirds of the area that was forested in 1600.

The Forest Service is increasingly not only managing forests to provide a sustainable supply of timber but also for the conservation of other resources. The current movement in forestry and its focus for the future is forest stewardship. Another way of saying this is sustainable forestry, but not just for the trees. It is sustainable forests as ecosystems, or ecosystem management rather than forest management. In ecosystem management, foresters must consider the complex ecosystems of forests and their roles as wildlife habitat, as watersheds, as recreational areas, as soil types that historically supported particular types of forests, and for their aesthetic value.

**Important Roles of Forests – Economic Value**

Our forest resources are renewable but we still must take great care in managing them, recognizing their true value, and not abusing them. Forests have immeasurable economic as well as ecological value.

The greatest economic contribution of our forests is in the forest products derived from trees. Our society is wood oriented. Our forests provide the timber we use to build our houses and other structures, pulp for the paper we write on, fuel in various places throughout the world, and other substances such as medicines and dyes. It has been estimated that forests provide more than 300 billion dollars worth of goods alone each year. Cereal and other food boxes, sports equipment, furniture, and flavorings are just a few. Wherever you look there are wood products. Stop for just a minute and think about all of the paper or other wood products you use in an average day. Americans use enough paper and wood products each year to fill a train of two million boxcars circling the Earth at the equator. One can easily see that Americans are very dependent on wood and wood products.

On the global scale, more than half (55%) of the timber cut each year is used for heating and cooking. This timber is in the form of fuelwood and charcoal. Charcoal is often used in urban areas of developing countries for cooking, heating, and in some industries.

Approximately one-third of the timber cut is in the form of sawlogs. These logs take the form of various building materials such as lumber, plywood, hardboard, particleboard, chipboard, veneer, poles, railroad ties, and piling, to name a few.
Lumber is used to make furniture and other manufactured items. One-sixth of the timber harvested is used as pulpwood to make paper products and a multitude of other products. Through chemistry, wood is used to produce a variety of products, including cellophane, rayon, plastics and other well known products. Approximately 66% of the paper produced comes from harvested logs; 30% comes from recycled paper, and 4% from non-wood sources such as cotton or rice straw. Treeless paper and paper that contains more recycled paper is becoming increasingly common.
Less well known, but not to be overlooked, is the value of forests for cattle grazing, medicinal plants, and floral and nursery products. Forests are made of all kinds of plants, some of which offer financial return, as do the trees. Ginseng, found in the mountains, is a valuable medicinal plant and has a large export market. Sassafras root and leaves and many herbs are valued in some areas. Ferns, galax, weeds and Spanish moss are used in floral arrangements. Gum from sweet gum or red gum trees is purchased in some areas.

The market for Christmas trees, mistletoe, pinecones, holly, and evergreen branches, during the holiday season, is a market North Carolina has increasingly tapped.

Pine straw is sold for landscaping. “Lighter” wood, the pitch-laden wood of pines, is sold in some markets for starting fires in fireplaces, as is wood for fuel. The cutting and sale of barbecue wood and fire wood can also provide a profit for the small landowner.

Wild fruits and berries can provide income, as can mushrooms. There is also a limited demand for tree pollen of various species for use in allergy treatments. The small forest landowner can also benefit from the removal of small hardwoods to be sold to nurseries and the public.

The demand for wood and wood products continues to increase. The demand for paper products has doubled since 1950 and is expected to double again by 2010. As the demand for wood continues to grow we must manage our forest resources carefully. Timber is a renewable resource but it cannot be abused and continue to meet our demands and wants.

**Ecological Benefits of Trees**

Economically, our forests are very valuable. We can easily see the products they provide for us and understand our dependence on them. In reality, we are much more dependent on our forest then we realize or acknowledge. The ecological value of our forests cannot be measured as easily as their economic value.

**Control of Runoff**

The leaves and branches of trees break the impact of rain. The moisture drips off rather than reaching the soil with a lot of force. Forested areas act as huge sponges that absorb precipitation, because the ground litter and humus of the forest floor absorb the water and decrease runoff. The litter and humus keep the soil mellow, porous, and permeable, allowing the seepage of water into the soil where it is stored. The roots of the trees hold the soil in place so that it can absorb the water. In these ways, trees slow down the rate of water flow off the land and allow some to return to the groundwater, helping to regulate stream flow and act as natural filtering agents.

**Prevention of Soil Erosion**

On bare soil the amount of water absorbed during a heavy rain is less than in the forested area. The pounding rain and rapid runoff over the land surface loosens and
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picks up soil particles. This results in muddy water entering streams and rivers. Forest trees reduce the amount of erosion, and the water that moves through forest soils does so more slowly. This reduces the amount of sediment and other pollutants that are washed into the streams, rivers, and lakes.

Retention of Snow Melt
In areas of the country where heavy snowfalls occur, forests help slow snow melt for up to several weeks longer than in open areas. Forest soils also tend to freeze less deeply, allowing more water from the melting snow to be absorbed. By delaying the snowmelt and by absorbing the water, forests prolong the period and decrease the amount of runoff, thus helping reduce flooding and equalizing stream flow in the rivers and streams.

Flood Prevention and Water Flow
Forested watersheds with good management practices do not typically have extremes of water flow in winter and summer and thus aid in flood control. Areas that are poorly managed or where forests are depleted in the headwaters experience heavy flows of rain carrying topsoil downstream in flash floods. This affects aquatic life and reduces the productivity of the streams and rivers for many years. Forest streams usually have little sediment, even during times of high stream flow.

Influence on Climate
Forests influence our climate, perhaps globally and certainly in a localized area. They keep the forest cooler in summer and warmer in winter than open areas, and the same variations are true for daily fluctuations. Air is more moist in the forest, because trees release moisture by transpiration and break the force of the wind, resulting in less evaporation from the forest soils. During the winter, the forest soil is less subject to frost because litter and humus act as an insulating layer.

The climate of an area can be greatly influenced by the amount of forests it has. In the tropical rain forest 50-80% of the moisture in the air comes from transpiration and evaporation carried out by the trees in the area. Anytime a large area of forested land is cleared, the annual amount of precipitation decreases and the area’s climate gets hotter and dryer. The soil becomes drier and is more likely to be eroded away, because there are no longer tree roots to hold it in place. Over time an area that was once a lush, green forest can turn into a grassland or even a desert due to climate changes caused by the loss of the forest.

Temperature Differences in Cities and Homes
Residential areas of cities typically have more trees than the downtown areas. Those trees play a role in the temperature differences between the two areas. The shade of a tree will typically make temperatures about 15 degrees cooler. The heat that is absorbed during the transpiration process also cools the air in the immediate vicinity.

Trees can significantly reduce the amount of energy consumed in buildings. A tree with its leaves is very effective at blocking out the sun’s radiation. It can block out up to 95% of the sun’s radiation and even a tree without leaves can block out up to 50% of the sun’s radiation. Trees are more effective at cooling a building than
blinds, plastic coating, or heavy coatings on glass. In fact, if trees were planted around each house in the United States, homeowners would save an estimated 15 to 50% (or approximately 4 billion dollars a year) on heating and cooling bills. Trees reduce the wind speeds thus making heating and cooling even more efficient.

**The Cycling of Essential Nutrients**

Forested areas also play an important role in the cycling of nutrients, particularly carbon. Forests take up approximately 90% of the carbon dioxide (CO₂) removed from the atmosphere. Trees and other plants use carbon dioxide, along with water and sunlight, in a process known as **photosynthesis**, to make their own food. A byproduct of this process is oxygen, the atmospheric gas necessary for all animals. The carbon is stored in plant tissues during their life and returned to the ecosystem by decomposers as leaves, needles, branches, or the entire tree, decays. The carbon is released as carbon dioxide when wood is burned to clear land or as fuel.

Other essential nutrients including nitrogen, phosphorus, and sulfur are stored in the trees. These nutrients are also released by decomposers to be reused by the biotic portion of the ecosystem.

**Removal of Air and Other Pollutants**

Trees also act as a filter for the air, reducing the amount of air pollution. The leaves and needles of trees absorb significant amounts of particulates from the air. They also reduce wind velocity allowing dust particles in the air to settle out by gravity.

The amount of carbon dioxide a tree takes in and uses is becoming increasingly important, because the amount of carbon dioxide in the air continues to increase as we burn more and more fossil fuels. More carbon dioxide in the atmosphere could cause the temperatures on earth to increase through the greenhouse effect. The role of forests in global warming is being debated. At least one study by Duke University has shown that some trees grow faster and better in air that contains more carbon dioxide. This study found that young loblolly pines grew 25% faster in air that was richer in carbon dioxide. The test air was meant to represent the level of carbon dioxide expected to be in the air in 2050. The scientists cautioned that the growth would probably level off as the trees mature and that the trees’ ability to absorb the carbon dioxide was not an ultimate answer to global warming, because most trees do not grow as quickly as the loblolly. The study does, however, indicate the important role that trees can play in reducing the amount and type of air pollution.

**Wildlife Habitat**

Another ecological benefit of forest is the **habitat** they provide. Trees provide homes, food, and shelter for hundreds of animals. In fact, forests provide habitats for more wildlife species than any other biome in the world. Some species of wildlife become endangered or extinct when the forests are removed.

Other types of forest vegetation or forests in varying stages of succession favor other species of wildlife. Some are dependent on grasses, shrubs, weeds, and young trees. These species benefit from periodic burns or the management of the forest to have varying age stands of trees or open areas.
Songbirds are an example of these species. Many songbirds, including neotropical migratory species are dependent on our forests for breeding and raising their young.

**Water Quality and Fish Environment**
The canopy of forest vegetation along waterways shades the water from the full heat of the sun keeping water temperatures cooler. This is important for certain species of fish, such as trout, that cannot tolerate warm waters. The removal of trees from creeks and streams, in the past, resulted in problems for these fish.

Trees also help prevent erosion keeping streams clear of pollutants and sediment that are undesirable for fish and other aquatic life. Sediments in the water can suffocate fish eggs, insect larva, and mollusks. Sedimentation is North Carolina’s number one water pollutant by volume.

**Noise Abatement**
Forests also help buffer the noise pollution created by cities and industries. All of the individual parts of the trees absorb excess sounds. They are especially good at absorbing high frequency sounds that humans don’t like, such as the noise of cars along a highway. A belt of trees 98 feet wide and 49 feet tall has been shown to reduce highway noise by six to ten decibels. The belt of trees reduced the noise from the highway by almost 50%. Trees not only absorb some of the noise made by humans, they also create noises themselves. The noise produced by the trees, such as the wind in the leaves or the birds singing in the tree, are often much more pleasant than the noise produced by humans.

**Greenbelts for Moisture Storage Zone**
Urban planners are increasingly using greenbelts of trees and other plants around cities. These areas provide moisture storage zones and allow water to infiltrate the soil returning it to the groundwater and affecting the quantity and quality of runoff. This is extremely important in cities where water runoff is high. Water can be diverted from streets and parking lots to these storage zones. A mature oak tree pumps water from the soil and can transpire 100 gallons of water during a hot summer day allowing the soil to store additional runoff.

**Reduction of Wind Erosion**
In windy open areas, trees make effective windbreaks. A row of trees, with dense foliage, 20 feet high can reduce the speed of the wind up to 400 feet. The windbreaks are used to protect crops, homes, barns, and livestock from hot or cold winds and blowing snow. The trees also reduce the harmful effects of the wind in drying out and blowing the soil. This helps prevent the loss of valuable topsoil and the covering of fertile soil or crops with sand.

**Reduction of Glare and Reflection**
Particularly in cities, trees are used to provide effective barriers to excessive glare and reflection from surfaces such as concrete and glass.

**Social, Recreational, and Aesthetic Value**
Forests also provide areas for humans to enjoy. We use our forest resources as parks and other places to escape into nature. People enjoy our forests for hiking.
biking, camping, nature study, bird watching, photography, picnicking, hunting, fishing, and also enjoy them for their scenic and aesthetic value.

Trees enhance property values. Whether in a city, a development, or a rural area, the presence of trees on the property makes it more appealing to buyers.

In summary, trees provide many ecological benefits. They help regulate the amount of water runoff, impact the climate of an area, play important roles in the cycling of nutrients, reduce pollution, provide habitat for wildlife, and places for people to enjoy nature. It has been estimated that a typical tree provides $196,250 worth of ecological benefits during its lifetime. These benefits occur as oxygen, air purification, soil fertility, erosion control, water recycling, humidity control, and wildlife habitats. If the same tree were cut down and sold as timber, it would only be worth about $59.00. The ecological value of our forest resources has been disregarded for years. It has only been recently that we have begun to acknowledge our dependence on the forest, its resources, and the services it provides for us. The ecological value of the forest is not a widely shared worldview. The goal of forest stewardship is to have the public view forests for their true value and to see the forest not for its immediate economic value but for its more important long-term ecological value.

**Kind or Stage of Forest**

Forests vary based upon topography, elevation, history, soil characteristics, exposure, and drainage. Some trees can tolerate wet conditions and will be the species found in wetland areas or bottomland forest, such as willow oak, river birch, water ash, and black tupelo. Others can tolerate the temperatures and conditions of our state’s highest slopes. These are the **boreal forests** or spruce-fir forest of our highest altitudes. Despite the type of tree, the kind of forest will depend on the stage of succession, or biotic change, based on the age of the forest and the typical progression for the area. Each kind of forest has associated vegetation, vertical structuring, and wildlife for which it provides favorable habitat.

**Young Forests and Openings**

This forest results from a disturbance or land-use change and ranges in age up to 10 years. Hurricanes, tornadoes, ice storms, fire, or human actions, such as abandoning fields or pastures, or logging and reseeding can be the causes of this age of forest. The young forest has many young trees, weeds, wildflowers, native grasses, and some shrubs and brambles.

The plants and characteristics of this forest provide food and cover for wild turkeys, rabbits, grouse, deer, bear, and many songbirds including bluebirds, goldfinches, song sparrows, and indigo buntings. Insects are plentiful, making these excellent areas for birds to raise and feed their broods.

**Middle-aged Forests**

The middle-aged forest is made up of trees of relatively small diameter. Some of the grasses, weeds, and shrubs have been shaded out giving this forest the
characteristic of a more open woodland area. This period usually ranges from 10 to 70 years. As the forest develops, leaf litter begins covering the forest floor, and the brushy cover understory and food for small wildlife becomes scarcer. The midstory tree level produces an increased amount of mast, seeds and fruits, including wild cherry, wild grape, and flowering dogwood.

**Mature and Overly Mature Forests**

The mature forest is characterized by trees of large diameter and a diverse understory. Development of the understory may result from the natural thinning process that removes suppressed or damaged trees, due to disease or insects, or selective timber harvesting. The falling of larger trees allows more sunlight to reach the midstory or forest floor. The light encourages the growth of woodland wildflowers, ferns, and shrubs such as huckleberry and blueberry. Wildlife benefits from the understory development. Mature forests may remain for a century or more until disease, insects, age, pollution or other factors begin the cycle again.

An important component of a mature forest for wildlife is the **snags**, which are standing dead or partially dead trees. Hard snags are trees that have died recently and still retain some limbs, are mostly sound in their interior, and have fairly intact outer bark. Soft snags typically have no limbs, little remaining bark, and are in advanced stages of decay. These trees are important feeding and nesting sites for insect-eating birds. Mature forests also have cavity trees, or den trees. These are live trees that have at least one nesting site. Mature, large trees with some type of damage, such as broken off tops, large broken off branches, large wounds or scars, or holes make good cavity nesting trees. These trees can provide permanent shelter for squirrels, raccoons, opossums, flying squirrels, owls, or even gray foxes. They are also the sites favored for seasonal dens by North Carolina’s black bear.

Downed logs of the mature forest are an important **microecosystem**. We are becoming more aware of the importance of rotting, downed logs. They become habitat for a variety of bacteria, fungi, and insects, which live under its bark or within its tissues. Downed logs are used by wildlife for nesting, foraging, roosting, perching, hiding, feeding, and displays. A wide range of animals from insectivorous birds to game animals use these logs. Woodland salamanders may lay their eggs under the moist decaying log, snakes may hide under them, rabbits may use holes in them to hide, insects, spiders, shrews, squirrels may sit up on them eating a nut, birds use them looking for insects to eat, lizards, and many more animals.

The downed logs are important for another reason. As the bacteria and fungi, the decomposers, break them down, essential nutrients are returned to the forest ecosystem to aid the growth of new vegetation. Some new trees, ferns, or weeds may actually be found growing on the downed logs.

These forests offer a wide variety of recreational opportunities including hunting, birding, wildlife observation, wildflower enjoyment, and nature study. The mature forest trees can also produce good sawtimber for homebuilding and furniture.
Succession (Biotic Change)

Change is the one constant in all communities and ecosystems. Succession is the regular pattern of change over time that takes place in an ecosystem. Because we do not know the normal range of most variables in an ecosystem or the effects of small, random events on changes in ecosystem structure and function, ecologists prefer the term biotic change. In forest ecosystems, succession begins with an area of bare ground. Over time different plants and animals come into the area and change the type of ecosystem that is present.

Primary succession occurs in areas where there is no life present. Examples of such areas include cooled lava fields and bare rock. Primary succession generally happens in a set sequence with little variation from ecosystem to ecosystem. Primary succession is a process that takes place over hundreds of years.

The first step that must happen is the formation of new soil. Lichens and mosses are usually the first organisms to come into an area. Lichens are fungi and algae living together in a relationship where both organism help one another. They are able to live on bare rock, because they produce an acid that breaks down the rock and organic material. Lichens are known as pioneer species, because they are the first organisms to inhabit an area. The rock of an area can also be broken down by wind and water in a process known as weathering.
As the soil is formed, more plants begin to grow in the area. Weeds, grasses and other small plants, such as herbs and small shrubs are usually the first plants to grow. Their seeds are carried into the area by animals, such as birds, or by the wind. These new plants help in the continued development of the soil by adding nutrients and organic material. The roots of these new plants also help to keep the newly developed soil in place. As the size of the grass and other small plant populations increases, the size of the lichen population decreases. This happens because the grass prevents the lichens from getting an adequate amount of sunshine, which is necessary for photosynthesis. The lichen community is replaced by a weed and grass community. Animals that are common in this newly formed grass community include insects, mice, deer, ground nesting birds, and hawks. This grass community occupies the area for many years. It is constantly adding more organic material to the soil, making it deeper and more fertile.

When the soil is deep enough, larger plants begin to grow in the area. These plants include larger shrubs and small woody plants. These plants grow taller then the grasses and small shrubs and thus compete with them for the sunlight. Eventually the majority of the grasses and small shrubs die out and the grass community becomes mainly a shrub community. Common animals in this shrub community are seed eating birds and snakes. A variety of plants and animals do not live in these shrub communities. They are not very stable and small changes can drastically disrupt life in these communities.

Shallow rooted pine trees begin to grow in the area, from seeds carried in by wind and animals, as the soil continues to become deeper, more fertile and better developed. Tree roots help weather the rock by entering small cracks, enlarging them, and allowing more water to enter. Again the community changes as the new pine trees block out the light from the large shrubs. The animals that live in the area
also change. Common animals in this new pine forest include the gray fox, rabbits, deer, hawks, and owls. Some of the smaller plant life continues to grow in this area but they are no longer the dominant plant species.

Over time the seeds of broad leaf (or deciduous) trees find their way into the area with the help of animals and the wind. A mixed forest grows for a period. The deciduous trees eventually overrun the pine forest and the area turns into a mature hardwood forest. The mature hardwood forest is the last step in succession. Trees that are common in hardwood forests include oaks, hickories, beeches, and maples. Animals that live in a mature forest include squirrels, deer, turkeys, bobcats, owls, chipmunks, raccoons, and opossums. Once this step of succession is reached the community is known as a climax community. Ecologists now prefer the use of mature community, as any community continues to change. A climax or mature community is a diverse community that does not undergo further succession although parts of the community will cycle through this process again as age, disease, or other factors open up parts of the forest. Climax communities are relatively stable and provide habitats for a wide variety of plants and animals. Small changes still occur within a climax community, but the dominant plants and animals will remain the same unless the forest is significantly disturbed. Some examples of possible disturbances are fire, clear-cutting, and disease.

Sometimes an area experiences a major disturbance and the plant and animal life changes. Such an area would then undergo another type of succession known as secondary succession. Secondary succession is the pattern of change in an ecosystem where a community has previously existed. The plants and animals from the first ecosystem have been cleared away by a disturbance, but the soil remains in place. Because the soil is still in place, secondary succession occurs much faster than primary succession.

The first step in secondary succession is the growth of pioneer species such as weeds and grasses. Lichens and mosses do not play a major part in secondary succession because the soil is already present and capable of supporting plant and animal life. The area then follows the steps in primary succession until it reaches a mature hardwood forest. The first stages of secondary succession happen quickly but it still takes years for the area to become a climax community. Nature carries out succession constantly despite the things humans sometimes do to try to stop it. Examples that show nature’s will for succession to occur can be seen in grass and weeds that grow up through driveways or the sidewalk.

In nature, all areas are not in the same stage of succession. An area where two ecosystems in different stages of succession meet is called an ecotone. Ecotones are often home to a wide variety of wildlife. By providing different types of vegetation, these areas are better able to meet more habitat needs for food and cover for an increased variety of species. Ecotones not only have a wider variety of wildlife, but they also usually have a high population density of wildlife, which is more animals living in a smaller area. These two characteristics (the greater variety of wildlife and greater population density) are collectively known as the edge effect. Some examples of ecotones are where dry land meets a lake or where open fields border a forest.
Forestry – “In wilderness is the preservation of the world” Henry David Thoreau

Secondary Succession and Habitat Chart

Forest Ecology
Ecology is the study of how living things interact with each other and with their nonliving environment. Forest ecology examines forests as biological communities, the interactions of various trees with other organisms in the community, and interactions between all of the species and their environment. Simply stated, forest ecology is the study of the forest ecosystem.

An ecosystem is all the living things in a particular area and the environment in which they live. Living things within an ecosystem are referred to as the organic or biotic factors. The environment or nonliving elements are referred to as inorganic or abiotic factors. There is continual interaction between and among all elements of an ecosystem. Man’s impact is sometimes referred to as anthropogenic factors.

The biotic portion of the forest is made up of all the trees, shrubs, wildflowers, ferns, other plants, fungi, mammals, birds, reptiles, amphibians, insects, worms, other invertebrates, as well as the bacteria and other microscopic organisms. All of these living things are dependent upon each other for life in the forest.

The organisms within the forest ecosystem may be **producers, consumers, or decomposers**. **Producers** are green plants and can make their own food. They are essential to almost all other life forms, because they are the base of the food chain. **Consumers** are animals that eat plants or other animals. Herbivores convert plant tissue into animal tissue that is consumed by carnivores. Thus many consumers provide the food supply for all other consumers. When the producer or consumer dies, the **decomposers** break down the plant and animal matter to be recycled through the ecosystem. In doing so, they are vital to the cycling of nutrients essential for plant and animal growth, such as carbon, nitrogen, phosphorus, and sulfur. Bacteria and fungi are the decomposers.
Many organisms have developed relationships in which they live together or in close association. This is called **symbiosis**. There are three types of symbiosis: mutualism, commensalism, and parasitism. Mistletoe, a plant, is a parasite, which lives on certain trees, as is the tick that lives on the deer or raccoon. Lichens found on some logs are a mutualistic relationship between an algae and a fungus. A commensalistic relationship exists between some plants, such as ferns, and trees that provide the shade and moisture they must have for survival. Epiphytes or air plants also have a commensalism association with trees.

*A special symbiotic relationship exists between trees and the fungus mycorrhizae.* The presence of these fungi in the soil combining with tree roots is essential for successful growth of many tree species. It is particularly true where soil moisture and phosphorus are limited. Mycorrhizae on roots enable trees to more fully utilize water and nutrients, particularly phosphorus and nitrogen, in the soil. These roots also play a role in the transfer of water and nutrients between trees.

Other relationships between the organisms of the forest include competition and predator-prey. Animals and plants have developed different methods to deal with the competition for resources, and animals have adapted various skills to capture prey or elude capture in the predator-prey relationship. Competition may be between members of the same species or different species. Trees, like all plants, compete for moisture, sunlight, and nutrients. Some trees, such as the black walnut, release chemicals into the soil that prevent others from growing too close. Animals compete for food, cover, breeding sites, and space or territory. Animals, such as warblers, use resource partitioning to avoid competition. Different species of birds spend the majority of their time feeding in different levels of the tree.

Trees, like all species, have levels of tolerance for various environmental factors. In silviculture, tolerance refers to a tree’s ability to withstand competition and develop and grow normally in the shade of other trees. Generally, hardwoods are considered tolerant and softwoods intolerant, but this is not true of all species of these groups. Trees’ tolerance may also relate to competition for soil moisture and nutrients.

Many animals such as deer, squirrels, and bears eat the nuts produced by some trees, and compete with each other for the necessary food resources. Trees produce an abundance of nuts so there are adequate numbers for reproduction and for these animals to eat. The tree also may benefit from this relationship. Nuts and acorns are known as **hard mast**. This mast enables animals like the bear to store enough fat to survive during its winter sleep. Other animals like the squirrel bury the nuts for food during the winter months. Not all of the buried nuts are eaten, and some eventually grow into new trees. Many are carried to new locations, which prevent competition with the parent tree.

Some animals have developed even more specialized relationships with the specific forest in which they live. The red cockaded woodpecker lives in mature longleaf pine forests that contain trees infected with redheart disease. The Northern flying squirrel only lives in the spruce fir forests found in parts of the mountain...
region of North Carolina. These animals are dependent on these habitats, and it is important to consider their needs in managing these forests. Both are on the federal endangered species list. They are endangered, at least in part, because of human destruction of and mismanagement of their habitats.

Ecosystems may cover a small area like a farm pond or a large area like a lake. Some ecosystems are simple. Others may be very complex with a lot of biodiversity, or large variety of plant and animal species. A pasture, a cornfield, or a loblolly pine plantation is examples of a simple ecosystem. Mixed forests of pines and hardwoods or mature oak-hickory forests are complex ecosystems. The more diverse or complex an ecosystem, the more resistant and resilient it is to change or damage by disease, storms, insects, fire, or other disasters.

A mature hardwood forest has many different plant species. One species may be attacked by a fungus and die out, but other species take its place. The entire forest is not lost, and the ecosystem will continue to function. Whereas, a pine plantation could be destroyed by an infestation of the southern pine beetle.

Within an ecosystem, there may be many microecosystems. These are small areas that are part of a larger system, with their own set of complex interactions occurring within them. A dead snag and decaying log are examples of microecosystems in a forest.

Abiotic Factors
The abiotic (or nonliving) portion of the forest ecosystem includes the air, water, soil, sunlight, climate, and essential nutrients. These things are not living, but they still are very important to the overall forest ecosystem. All of these help the plants and animals of the forest grow and reproduce. Some abiotic factors help filter pollutants from the environment and thus provide some protection for the organisms.

Climate is a major abiotic factor. Each type of tree has a limit of tolerance for climatic conditions. Spruce fir or boreal forests grow only at the highest elevations in North Carolina. Longleaf pine forests grow on the coastal plain.

Sunlight is important in the rate of plant growth, since it is necessary for photosynthesis. The quality, intensity, and duration of light affect photosynthesis. The photoperiod, or day length, influences photosynthesis and the growth rate of trees. The long hours of daylight in spring and early summer result in rapid growth. Light distribution also affects the tree’s growth. Trees will develop more foliage on the lighted side. Some tree species require lots of direct sunlight, while others, referred to as shade tolerant, need very little sunlight to grow properly. The amount of available sunlight plays a major role in determining where different species of trees will grow.

In addition to sunlight, atmospheric gases play a role. Carbon dioxide is essential for photosynthesis as is oxygen for respiration. Air pollutants, such as sulfur oxides and nitrogen oxides, combine with water to produce acid precipitation. Acid rain and other forms of precipitation can harm the forest’s trees by damaging
their leaves or needles, decreasing the rate of photosynthesis, and by increasing the acidity of the soil.

Water is essential for all plant growth. Available water is the most limiting element of all the abiotic factors on tree growth. Trees require large amounts of water for transpiration and photosynthesis. Too much water can also be a problem. Tree roots take in oxygen from the soil. Some trees are more tolerant of wet conditions while others can live in rather dry areas. Trees which can survive having their roots in wet conditions include red maples, beech, and birch. The wetness of an area a tree can tolerate determines which species will grow in certain locations.

**Photosynthesis and Biochemical Cycles**

**Photosynthesis** is the process carried out by plants, algae, and blue-green bacteria to make food from sunlight, carbon dioxide, and water. These organisms use the sun’s light energy to make their food and provide the food for most all other organisms on the earth. Photosynthetic organisms are the *producers*.

Other organisms obtain the energy they need by eating plants or another organism that ate plants. These organisms are *consumers*. The stored chemical energy produced during photosynthesis is released by the process of *respiration*. The sugar made during photosynthesis is broken down with the use of oxygen to produce energy, carbon dioxide, and water.

These two processes, photosynthesis and respiration, are the opposite of one another. Both processes are essential for all life, and ultimately most all life is dependent on the sun’s energy, which makes photosynthesis possible.

\[
\begin{align*}
\text{Carbon Dioxide} + \text{Water} + \text{Sunlight} & \rightarrow \text{Sugar} + \text{Oxygen} + \text{Water} \\
& \quad \text{(Glucose)} \\
\text{Respiration} & \rightarrow \text{Sugar} + \text{Oxygen} \rightarrow \text{Carbon Dioxide} + \text{Water} + \text{Energy} \\
& \quad \text{(Glucose)} \\
\end{align*}
\]

There are many nutrients necessary for life, but six are commonly recognized as very important: C (carbon), H (hydrogen), O (oxygen), N (nitrogen), P (phosphorus), and S (sulfur). These elements are essential for the growth and health of a forest ecosystem. Another element, K (potassium), is an important factor for tree growth.

Nutrients are continuously cycled through the ecosystem where they are used again and again by the living organisms. The plants, animals, and other organisms use nutrients for their life processes. The nutrients are then returned to the ecosystem from waste matter excreted or from the organisms’ bodies when they die. Some organisms, the bacteria and fungi, break down dead organic matter and return the nutrients to the ecosystem. These organisms are the *decomposers*. 
**Forestry** — “In wilderness is the preservation of the world” Henry David Thoreau

**The Biochemical Cycles**
(C, H, O, N, P, & S continually cycle through the biota and abiotic parts of an ecosystem.)

**Forest Soils**
The soil is another important abiotic factor in the forest ecosystem. The soil anchors the tree and serves as its growth medium. It also provides water and nutrients essential for growth. Soils found in forests can vary greatly. Today, most forests are found on relatively poor soils, because the better quality soils are used primarily for agriculture. The soils found in these forests tend to be sandy, rocky, poorly drained, or swampy. They may be deficient in their levels of phosphorus, nitrogen, and potassium. For example, the soil in pine forests tends to be slightly

**The black locust is a nitrogen fixing species.**
acidity. Some species, such as the black locust, are able to fix nitrogen, thus adding this nutrient to the soil. There are several different factors that determine the quality of the soil within the forest ecosystem. Soil texture, chemical composition, structure, depth, and position affect the supply of moisture and nutrients within it and influence tree growth.

- Top soil depth- the top soil is the uppermost layer of soil, under the litter usually found on the forest floor. It plays a major role in the amount of tree growth that takes place annually.
- Soil texture- Soil texture refers to the amount of sand, slit, and clay that the soil contains. This affects the soils ability to hold nutrients and drain water through the soil. Coarse-textured, sandy soils have low water-holding capacity and nutrient content. In fine-textured clay soils, water-holding capacity is good, but aeration may be low under wet conditions. This creates a problem for chemical processes requiring oxygen in the roots.
- Limiting Layers- a limiting layer in the soil is a layer that stops the roots of trees from extending downward anymore. Limiting layers can severely decrease overall tree growth and health.
- Drainage- The drainage of a soil also plays a role in plant growth. Most plants and trees do not grow well in soils that are constantly wet. The texture of a soil determines how well it will drain. For example, sandy soils drain faster than clay soils.

The soil also contains some microorganisms that are important for plant growth. Mycorrhizae fungi, which attach to plants’ roots, convert atmospheric nitrogen to a usable form and aid in water and nutrient uptake. The soil absorbs excess precipitation and prevents some flooding. It filters out some of the pollution made by man and protects organisms from harm. The soil provides a home for a wide variety of organisms, including the decomposers, which keep the forest floor clean by feeding on the dead and decaying material found there and recycle the essential nutrients.

The trees also have an important impact on the soil. The roots of trees and other plants help hold the soil in place and prevent erosion.

**Limiting Factors**

Limiting factors are things that limit the growth of living organisms within an ecosystem. In addition to the abiotic factors mentioned above, other limiting factors in the forest ecosystem are the amount of precipitation an area receives, the amount of available sunlight, the amount of available nutrients, the denseness (spacing or arrangement) of the trees, and the number of organisms living in the forest. The denseness, or spacing of organisms in the forest, is important because it affects the competition for resources between organisms. Denseness therefore affects the overall growth due to limited nutrients necessary for the plants to grow and thrive. Trees in a dense forest will not grow as tall or be as healthy as those that are well spaced.
Developmental Stages

The stands of trees in a forest vary by composition (tree species), density, and age. A stand that varies little in age is called “even-aged.” Stands with greater variation in age, one to 100 years or more, are called “uneven-aged” stands.

Specific developmental stages can be recognized in an even-aged stand.

- Seedling stage – from seed to 5-15 years, the beginning of the closing of a stand.
- Sapling stage – from the closing of the stand to death of lower limbs and crowns well above the ground.
- Pole stage – from sapling stage to limb clearing of most of the trunk and decline in height growth.
- Young timber stage – from time of slowed height growth to full height growth.
- Mature timber stage – from time of complete height growth to beginning of decline in quality and volume.
- Over mature timber stage – from start of deterioration in the stand.

Crown Classification

Trees in a stand can also be classified by the cover formed by tree crowns or the position of the crown in the forest canopy. The tree species, age, health, and competition are important factors in crown position.

Dominant – Crowns of larger trees, forming upper level of the canopy and receiving light from above and partially from the sides. These trees are also referred to as emergent.

Co-dominant – Medium-sized crowns that form the general crown cover or canopy and receive sunlight from above.

Intermediate – Small-crowned, shorter trees with crowns that just reach into the general canopy and receive little direct sunlight. These may also be referred to as the understory.

Overtopped – Small trees with crowns below the canopy, receiving no direct sunlight. These may also be referred to as oppressed, or as suppressed when they are not growing or are dying.

Isolated – Trees growing in the open with little or no competition.

Vertical Stratification

The average forest, or stand of trees, contains trees of different sizes and in different layers as mentioned in crown classification above. This layering takes place naturally and is known as vertical layering, or vertical stratification, and is important to the overall health of the forest. The development of layers provides a more diverse forest that meets the needs of various species of wildlife. Animals like voles, moles, and earthworms live in the ground. Foxes, deer, and salamanders live on the forest floor. Various bird species live in different layers of the trees along with animals, such as raccoons and squirrels.
The lowest surface layer of the forest ecosystem is the forest floor. It is covered mostly with fallen leaves, grasses, ferns, flowers, needles, and fungi. Other small plants and young trees, known as seedlings, may also be found on the forest floor. One of the most important activities that takes place on the forest floor is decomposition and its role in the cycling of many nutrients. The forest floor may also contain fallen logs that provide habitat to a large number and wide variety of organisms.

The next layer in the forest ecosystem is known as the understory, or intermediate layer. It contains small short trees, such as the dogwood and sassafras, shrubs, and other shade tolerant species. One important role of this layer is to provide cover and food for wildlife. This layer is sometimes called suppressed because the trees are limited in their growth due to lack of available sunlight.

The last layer is called the leaf canopy or crown cover. The crown, or tops, of all the trees in the forest make up this layer. These trees receive plenty of sunlight and block sunlight to the trees and other plants that grow in the understory. These trees are called co-dominant because they are all relatively the same height. Some trees will be taller than the other trees found in the crown cover. These trees are known as dominate or emergent.
**Forest Types**

Forests can be divided into two main groups: coniferous and deciduous, or softwood and hardwood. Coniferous trees are **gymnosperms** or plants that have “naked seeds.” These plants produce seeds on the scales of woody strobili called **cones**. The seeds are not protected by a fruit. Cones, instead of flowers, are produced. Deciduous trees are **angiosperms** or flowering plants. These plants have flowers and enclose their seeds in protective fruits. A third type of forest, a **mixed forest**, has both coniferous and deciduous trees.

*Coniferous forests* contain trees known as conifers. Conifers are **evergreen** trees with needle-like or scale-like leaves, and most bear seed cones. **Evergreen** trees keep their leaves all year. Leaves drop off as they are damaged or age. The tree does not lose all of its leaves at once, and they are replaced by new needles, as they are lost. Pine needles, depending on the species, may stay on the tree from two to 40 years. Cones hold the seeds of these trees. Coniferous trees, or softwoods, make up 33% of the forests found in North Carolina.

The needle leaves of conifers are an adaptation that helps them live in cold or dry habitats. The needles are covered with a thick cuticle that helps them conserve water. The needles also play an important role during the winter months. The branches and needles are very flexible and allow ice and snow to slide from the tree. Retaining their needles all year allows conifers to get a head start on growth when conditions are right, eliminates the need to grow a new set of leaves each year, and gives them the ability to conduct photosynthesis under rather poor conditions. The overall shape of conifers is another shared characteristic. Generally, they have a single trunk and are roughly shaped like a triangle, wider at the bottom.
The needles of coniferous trees can be very helpful in identifying tree species. Depending on the species, the needles occur in bundles of two, three, four, and even five. These bundles are joined together at one end. The length of the needles can also be helpful in identifying tree species. For example, the Virginia pine has bundles of two very short needles (1.5-3 inches), while the eastern white pine has bundles of five needles of longer length (2.5-6 inches). Cone size and shape can also be used to identify coniferous trees. Cone size varies from less than an inch to more than twelve inches long.

There are over 500 species of coniferous trees in the world. Some of the most common are pine, hemlock, fir, spruce, and cedar. Specific coniferous species found in North Carolina include the eastern white pine, shortleaf pine, loblolly pine, longleaf pine, pitch pine, Virginia pine, pond pine, table mountain pine, red spruce, eastern hemlock, Fraser fir, Atlantic white cedar, and eastern red cedar. Coniferous forests usually grow in dense communities with little diversity. Sometimes, a stand of coniferous tree will only include two or three different tree species. The denseness of the stand blocks sunlight from reaching the ground preventing many other plants from growing on the forest floor. The soil in coniferous forests tends to be slightly acidic. The needles from the trees are acidic; and when they fall off, they are decomposed into the soil. The acidic soil is another factor that limits the growth of other plants. A few other plants do manage to grow and live successfully with coniferous trees. These plants include ferns, lichens, and sphagnum moss. Coniferous forests do, however, support a wide variety of animal life. Common animals are mice, squirrels, insects, birds, deer, elk, beaver, rabbits, grizzly bears, and wolves.

Deciduous forests are also known as hardwoods. Deciduous trees have broad leaves that they lose during one season of the year, usually autumn. In fact, the term comes from the Latin word *deciduous*, which means “to fall off.” These trees have a growing season that lasts about six months. During this time, usually in the spring and summer, the tree has leaves and is growing rapidly and storing food to be used during the fall and winter months. This food is stored in the tree’s trunk, branches, and roots. In the autumn the shortening days cause a chemical change within the tree that causes the leaves to change color and eventually fall off. Deciduous trees are dormant and do not grow during the winter months. In the spring, warmer temperatures and longer days trigger another chemical change that causes leaves to once again grow. These new leaves immediately start to produce food for the tree to use and to store for the next winter.

Deciduous trees are flowering plants or angiosperms. Depending on the species, they produce incomplete flowers, which are either male or female; or they produce complete flowers that have both male and female reproductive structures. The flower is the reproductive structure that produces the seeds, and these trees enclose their seeds in a protective structure called a fruit.

North Carolina has more species of deciduous, or hardwood, trees than any other state in the United States. These species include oak, hickory, maple, ash, poplar, beech, birch, black gum, and many more. Deciduous trees are much more diverse than conifers. Hardwood trees make up 53% of the forests found in our state.
Deciduous trees can be identified by the shape and size of their leaves, their bark, buds, and the fruit. They are usually stratified, with different trees growing at different levels. Hardwood trees also support a wide variety of animals. Many of these trees produce the *hard mast*, nuts and acorns, which numerous animals rely upon for winter food and fat storage. Some animals commonly found in the deciduous forest are slugs, insects, birds, mice, lizards, snakes, squirrels, foxes, black bear, raccoons, deer, wolves, mountain lions, and opossums. A few conifers are deciduous trees, including the baldcypress and larches.

Either of these types of forests can be what is referred to as *old growth forests*. These are forests that have not been disturbed for hundreds or even thousands of years. Some examples of old growth forest found in the United States are Douglas fir, western hemlock, giant sequoia, and coastal redwoods in the west and loblolly pines and a few mountain cove hardwood forests in the southeast. Examples of old growth forest found elsewhere in the world are the boreal forests in Russia, western Canada, and Alaska and much of the tropical forests in the world. Old growth forests are not replaceable on our timetable. Therefore they are very limited and special. These forests were destroyed for years before their true value was recognized. In Europe two-thirds of the old growth forests have been destroyed and the United States has destroyed 95 to 98% of its old growth forest.

Old growth forests are important because they provide unique homes to a wide variety of wildlife species. They tend to be full of standing dead trees, called snags, and fallen logs. Many of the animals found in the old growth forests are endangered, and this can cause conflicts between conservationists and industry. One example of controversy is the spotted owl that lives in the old growth forests of the Pacific Northwest. The logging industry wanted to cut down some of the old growth forest to provide more products and jobs for people. Conservationists, on the other hand, wanted to preserve the old growth forest and used the spotted owl’s status as an endangered species to stop the logging industry.

A third type of forest occurs when coniferous and deciduous trees grow together in the same area. This is known as a *mixed forest* or multi-stand. The trees found within a mixed stand are generally of different ages and sizes, and they typically support a wide variety of plant and animal species. Mixed stands of oaks and pines account for approximately 14% of North Carolina’s forested land.

**Trees**

Trees are amazing organisms that have existed on Earth for more than 200 million years. Trees are also industrious organisms. Every year a tree produces 99% of its living parts. In part due to the capillary motion of water, trees can lift water up through their trunks at the amazing rate of one hundred fifty feet an hour. During the summer a tree can lift more than a ton of water each day.

**Parts of a Tree**

All trees are made up of three major parts: the roots, trunk, and crown. Each of these parts plays a vital role in the life and survival of the tree.
Forestry – “In wilderness is the preservation of the world” Henry David Thoreau

The majority of the roots cannot be seen from our perspective, but this does not diminish their importance. The primary functions of roots are to anchor the tree in the ground, to provide support, to store food for future growth, and to take in nutrients and water from the soil. Roots tend to grow in two patterns: surface-rooted and deep-rooted.
Surface-rooted trees extend roots laterally in a wide area below the tree. In some species, the roots are shallow in the soil. Some surface-rooted species include birch, elm, hemlock, and spruce.

Deep-rooted trees have **taproots** that extend down into the soil strata. Pines have taproots. The longleaf pine is less susceptible to being blown down by winds, than most southern pines, due to a taproot that extends deep into the soil. Most hardwood trees have a combination of taproots and lateral or surface roots which anchor them firmly to the soil. Hardwood species with deep taproots include hickory, oak, and walnut.

Roots grow continually to form a large network that works together to support the tree both physically and with nutrients and water. Larger roots grow smaller roots called rootlets, which act as an extension of themselves. In many species, the rootlets grow even smaller, fine, hair-like roots called **root hairs**. It is the root hairs that take in nutrients and water from the soil. Pine trees are the only type of tree that does not have root hairs. They however, have a special fungi living on their roots that aids them in taking in nutrients and water. The fungi are known as mycorrhizae. Mycorrhizae are found naturally in most soils and help to increase the mobility of nutrients in the soil and protect the tree from disease and infections.

**Trunk**

The trunk of the tree is readily visible to us. Its major purpose is to support the tree and to move materials. The water and nutrients absorbed by the roots are moved up the tree to the leaves where they are used to make food through photosynthesis. The food produced in the leaves is moved downward to nourish other parts of the tree. The trunk and limbs of the tree are covered by a dead layer of cells known as bark.

Bark can be divided into two layers: the outer bark and the inner bark. The outer bark protects the tree from extreme temperatures, bad weather, insects, fungi, other pests, disease, fire, and humans. The outer bark varies in thickness depending on the tree species. For example the outer bark of birch trees is very thin but the outer bark of the Douglas fir can be up to one foot thick. Under the outer bark is the inner bark, or **phloem**. The inner bark is soft and moist. Its major purpose is to move the food produced by the leaves down to the different parts of the tree, where it is used for growth or stored for later use. The bark of trees is useful to humans. It produces medicines, oils, and dyes.

Under the inner bark, is the **cambium**. The main purpose of the cambium is the actual growth of the tree. The cambium is a relatively thin layer of cells. The outer side of the cambium produces inner bark, or phloem, and the inner side of the cambium produces sapwood, or xylem. It is the cambium that each year forms new annual rings visible in a cross section of a tree’s trunk.

Sapwood, or **xylem**, is the living wood of the tree. Its major purpose is to carry nutrients and water to the crown of the tree from the roots. Extra food is stored in the xylem. This food is used by deciduous trees in the winter when they are
dormant. Coniferous trees use this stored food on days when there is little or no sunlight.

The next layer in is the heartwood of the tree. The heartwood is made up of old cells that are actually dead. It is usually darker in color than the other parts of the tree’s trunk. The major purpose of the heartwood is to provide support and to strengthen the tree. In most trees, the heartwood is the largest part in the cross section of the tree. Finally, the very center of a tree’s trunk is called the pith.

**Crown**

The branches, twigs, and leaves collectively make up what is known as the crown. The crown of a tree is important, because it is where photosynthesis, or food production, actually takes place. Once the food is produced, it is moved down through the branches, trunk, and roots to the growing parts of the tree. Two other processes that take place within the crown are transpiration and respiration. Respiration is the process by which trees convert food to energy used for growth. Oxygen is required for the tree’s respiration, but much more oxygen is released as a by-product of photosynthesis. This is one reason trees are so important in our daily lives. They help produce the oxygen we need to breathe. Over fifty years, one tree can produce more than 30,000 dollars worth of oxygen. Transpiration is the process by which water is released from the leaves to the atmosphere. This happens through small pores, or openings, on the backside of leaves called stomata. Over a period of fifty years one tree can recycle more than 35,000 dollars worth of water through various process such as transpiration.
The Leaf
The mesophyll contains the chloroplasts, where photosynthesis takes place. Most photosynthesis occurs in the palisade layer. Within the spongy mesophyll are vascular bundles, the vein of the leaf. These bundles contain xylem and phloem, which transport materials to and from the leaf. The upper epidermis is covered by a waxy cuticle to prevent water loss. The lower epidermis contains many stomata or pores with guard cells to control their opening and closing. During the day, carbon dioxide enters the stomata for use in photosynthesis. Oxygen also enters the stomata for use in respiration. Water vapor transpires and oxygen exits from leaves through the stomata.

Life Cycle of Trees
Like most plants, trees can begin life as a seed. Coniferous trees, or gymnosperms, grow exclusively from seeds found within their seed cones. Hardwood trees, angiosperms, can grow from either seeds or sprouts. Sprouts, or suckers, grow from underground roots of an existing tree, called the parent tree or from stumps.

Seed Production
In conifers (gymnosperms) the adult tree produces male and female cones on separate branches. Female cones develop two ovules on each cone scale. These develop into eggs. Male cones are small and easily overlooked. They produce pollen grains. The wind-blown pollen travels to the female cone. This is known as pollination. A pollen tube grows and a sperm cell, from the pollen, unites with the egg, in the process of fertilization. The fertilized egg, known as a zygote, develops into an embryo, and a mature seed is produced. The female cone opens releasing the seeds.

Within each seed is the tiny plant embryo and a food supply of starch for its development and growth. All of this is enclosed in a seed cover or seed coat. When a seed is placed in a favorable environment, with enough moisture and adequate temperature, germination occurs. The seed cover opens, and a tiny root extends down into the soil. This root holds the new plant in place and starts to absorb water and nutrients to aid the growth of the plant. At the same time, the tiny plant leaves are released from the seed cover and begin to grow upward toward the sun. In conifers, a new, young sporophyte – a pine tree seedling emerges.

Deciduous trees are angiosperms or flowering plants, and most produce both male and female flowers or complete flowers, which contain both male and female parts. Some, known as dioecious species, produce male and female flowers on separate plants. Seeds are formed when ovules within the ovary of the female portion of the
flower, the pistil, are fertilized by sperm from pollen grains produced in the anther of the male part of the flower, the stamen. Angiosperms enclose their mature seed inside protective fruits. Pollination, the transfer of pollen from the stamen to the pistil, is the first step in this process. Many animals, especially insects such as bees, are important in pollination, but wind is also a major vehicle for pollination for many trees.

Trees that grow from sprouts must grow close to their parent tree, but trees that grow from seeds may grow far away from their parent. Seeds can travel from place to place in a wide variety of ways. Some animals, such as birds, eat the fruit of trees and then deposit the seeds in their wastes. Other animals bury the nuts or acorns for winter food. If these nuts are not eaten during the winter, they sometimes grow into trees. Seeds can be blown to distant places by the wind or fall into streams and be carried away. They can also attach themselves to the fur or feet of animals and be carried from place to place.
Tree Development
If seeds are carried far away from their parent tree, there is no competition between the parent tree and the young tree. Trees produce thousands of seeds each year. Not all of these seeds grow into trees. Excess seeds are produced to ensure that there are enough for wildlife consumption and to ensure the survival of the tree species. If seeds do find a suitable place to grow, their battle is not over. Once a seed enters the next stage of its life and becomes a small plant, called a seedling, it finds itself in competition with other plants and animals for sunlight, food, water, and nutrients. It must also fight off disease, insects, and other pests for survival. Only a small percentage of seedlings actually survive to mature into a full-grown tree.

A seedling grows into a sapling. Its chances for survival are much greater once it reaches this stage in life. A sapling can grow into a mature tree. A mature tree can live for decades or up to hundreds of years. When the mature tree dies, it becomes a dead tree and then a decaying stump or log. The dead trees and decaying trees provide habitat for a wide variety of wildlife.

Identifying Trees
There are many things that should be considered when identifying trees. Usually a combination of characteristics is used to correctly identify a tree species. Some of these characteristics include leaf shape, position of leaves, type of leaf margins, type of fruit, twigs, the silhouette of the tree, and the appearance of the bark. When identifying coniferous trees it is helpful to look at the length of the needles, the number of needles in each bundle, the silhouette, and the bark of the tree.

Conifers can be identified by their needles. The size and shape are good clues. The length and number of needles per bundle is most helpful in identifying pines. Conifers may also be identified by their cone size and shape, tree silhouette, bark, and arrangement of limbs.
Deciduous trees can be identified using many characteristics. The following assist in identification: leaf size, shape, arrangement, and margins; buds, twigs, limbs, growth pattern, seeds, fruits, and bark.

**Leaves**
Trees can be identified by type, size, shape, texture, color, margins, venation, and arrangement of leaves. Leaves may be arranged in an alternate, opposite, or whorled pattern. They may be simple, one blade, or compound, several small leaflets per leaf. Leaf colors may also be helpful in autumn. Any good tree guide will show the various leaf shapes, margins, arrangement, types, tips, venation, and bases.

**Fruits**
There are two major groups of fruits, simple (individual fruit) and compound (a cluster of fruits in one receptacle). Simple fruits are classified as fleshy or dry. Fleshy fruits include the berry, drupe, and pome. Dry fruits may be dehiscent (pop open when ripe), including capsules and legumes; or indehiscent (not open when ripe), such as the achene, nut, and samara (winged fruit). Compound fruits may be aggregate, a cluster of fruit from one flower, or multiple, a cluster of fruits from separate flowers crowded together. See the picture of fruits on page 31.

**Twigs**
Twigs are particularly helpful in identifying trees in the winter. They have textures, arrangements, leaf scars and pith, buds, and bark that assist in identification. Some have distinctive tastes, colors, or smells.

**Buds**
Buds aid in winter tree identification. Trees produce buds with different sizes, shapes, colors, arrangement, and scaling.

**Bark**
Bark is perhaps the most important identifying characteristic of large trees in winter. The bark fissures or cracks into ridges, plates, or scales characteristic to each species. Bark also differs in thickness, color, texture, and odor.

**Flowers**
Some trees have distinctive flowers, such as the poplar and magnolia; but many flowers are very small and short-lived making them of little use for identification.

**Growth Pattern**
The crown shape, density, color, and branching pattern, as well as the tree silhouette can assist identification. Some species have rounded or umbrella shapes, others have drooping limbs, and some have pointed tops. Some tree species can tolerate wetland areas, while others prefer well-drained or even dry sandy areas. A good tree guide book will show the characteristic silhouette of each species.

The following tables provide information on some of North Carolina’s more common trees.
### Coniferous Trees – Softwoods

<table>
<thead>
<tr>
<th>Tree</th>
<th>Needles</th>
<th>Cones</th>
<th>Bark</th>
<th>Uses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eastern White Pine 100-200'</td>
<td>soft, bluish green, 3-5&quot; long, bundles of 5, on tree 2-3 years</td>
<td>4-8&quot;, long and curved</td>
<td>gray, smooth becoming rough, thick, deeply furrowed</td>
<td>cabinets, furniture, paneling, carving, lumber</td>
</tr>
<tr>
<td>Shortleaf Pine (aka yellow pine) 80-100'</td>
<td>3-5&quot; long, slender, dark green, bundles of 2 or 3</td>
<td>oval shaped, 1.5-2.5&quot; long, short spines at tip</td>
<td>reddish brown with large, irregular, flat, scaly plates</td>
<td>lumber, plywood, veneer, pulpwood, barrels</td>
</tr>
<tr>
<td>Loblolly Pine 90-110'</td>
<td>slender and stiff often twisted, 6-9&quot; long, pale green, bundles of 3</td>
<td>oblong, 2-6&quot;, reddish to brown color, spines at tip</td>
<td>blackish gray, thick, deeply furrowed into scaly ridges</td>
<td>pulpwood, lumber (among fastest growing pines of southeast)</td>
</tr>
<tr>
<td>Longleaf Pine 80-100'</td>
<td>bright green, 8-15&quot; long, bundles of 3</td>
<td>6-10&quot; long, cones tipped with spines</td>
<td>orange-brown, furrowed into scaly plates; Young-gray</td>
<td>Naval stores, lumber, poles, pilings, pulpwood</td>
</tr>
<tr>
<td>Pitch Pine 50-60'</td>
<td>dark yellow-green, 3-6&quot; long, bundles of 3</td>
<td>1.25-2.75&quot; long, tipped with curved rigid spines</td>
<td>dark gray, thick, rough, broad scaly ridges, deep furrows</td>
<td>lumber and plywood, historically for resin</td>
</tr>
<tr>
<td>Virginia Pine 50-80'</td>
<td>green and twisted, 1.5-3&quot; long, bundles of 2</td>
<td>oval, dark reddish brown, 1.5-2.75&quot;, spines</td>
<td>brownish gray, thin, narrow scaly ridges</td>
<td>pulpwood, lumber</td>
</tr>
<tr>
<td>Eastern Red cedar 40-60'</td>
<td>opposite in 4 rows, 1.5-10mm long, scalelike, dark green</td>
<td>6-10mm in diameter, berrylike</td>
<td>reddish brown, thin, fibrous and shreddy</td>
<td>fenceposts, chests, cabinets, carving, closet paneling</td>
</tr>
</tbody>
</table>
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### Deciduous Tree – Hardwoods

<table>
<thead>
<tr>
<th>Tree</th>
<th>Leaves</th>
<th>Bark</th>
<th>Fruit</th>
<th>Uses</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Red Maple</strong></td>
<td>3-5 lobed, thick, coarsely-toothed margins, 2-6&quot; long</td>
<td>dark gray, vertical ridges into large, plate-like scales</td>
<td>reddish, paired, winged fruit, V-shaped samaras</td>
<td>as ornamental trees, buds &amp; samaras are main food for gray squirrels, sprouts are deer browse</td>
</tr>
<tr>
<td>Height: 75-90'</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diameter: 1.5-2.5 ft.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Black Walnut</strong></td>
<td>alternate, pinnately compound, 12-24&quot; long, sharply oval, toothed, long-pointed leaflets 3-3.5&quot;</td>
<td>dark brown, deeply furrowed into scaly ridges</td>
<td>hard, woody nut, 1.5-2&quot; in diameter, dark brown, oval to oblong, single or in pairs, in a thick yellow-green husk</td>
<td>high quality furniture, gunstocks, interior finishes, and veneer. Mast for wildlife</td>
</tr>
<tr>
<td>Height: 100</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diameter: 2-3 ft.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Hickory:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bitternut - 100+ ft - Ht. 2-3 ft. - Dia.</td>
<td>6-10&quot;, 7-9 long oval, toothed leaflets 8-12&quot;, 7-9 thin, sharp-pointed leaflet 8-12&quot;, 5 fine-toothed, sharp pointed leaflets</td>
<td>smooth gray bark, becomes very rough and scaly on older trees, often separating into long strips</td>
<td>4 ribbed nut in husk, ~1&quot; long 1.5-2&quot; long nut in thick husk - reddish-brown globular to pear shaped 1.5&quot; nut in thin husk</td>
<td>tool handles, sporting equipment - bats, agricultural implements, furniture; Mast for wildlife</td>
</tr>
<tr>
<td>Mockernut - to 100 ft. - Ht. 3 ft. - Dia. Pignut - 50 - 75 ft. - Ht. 3-4 ft. - Dia.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Sweetgum</strong></td>
<td>star-shaped, up to 5, occasionally 7, deeply separated, pointed lobes</td>
<td>twigs often have corky wings</td>
<td>round, bur-like, hard, woody fruit; 1-1.5&quot; in diameter, on a long stalk</td>
<td>lumber (boxes, crates, &amp; baskets) veneer, plywood</td>
</tr>
<tr>
<td>White Oak</td>
<td>alternate; 4-9&quot; long, 2-4&quot; wide, elliptical; 5-9 lobed, widest beyond middle</td>
<td>light gray, shallowly fissured into long broad scaly plates or ridges</td>
<td>mature in 1 yr. acorns up to 1.25&quot; long; egg-shaped, enclosed by shallow cup, light gray with warty scales</td>
<td>historically - shipbuilding, flooring, furniture, barrels, kegs, handles, boxes, wildlife mast</td>
</tr>
<tr>
<td>-----------</td>
<td>-------------------------------------------------</td>
<td>-------------------------------------------------</td>
<td>-------------------------------------------------</td>
<td>-------------------------------------------------</td>
</tr>
<tr>
<td>Post Oak</td>
<td>3-6&quot;; 5-7 deep broad rounded lobes, 2 middle lobes longest, short pointed base, Obovate</td>
<td>light gray, fissured into scaly ridges</td>
<td>.5-1&quot; acorns; elliptical, .3-.5 encased in deep cup, mature in 1 year</td>
<td>marketed as white oak, railroad cross-ties, posts, construction timber, wildlife mast</td>
</tr>
<tr>
<td>Southern Red Oak</td>
<td>alternate; 4-8&quot; long, 2-6&quot; wide, elliptical; deeply divided into long narrow end lobes</td>
<td>dark gray, furrowed into broad ridges and plates</td>
<td>.5+ in. acorns, one-third or more encased in cup tapering to broad base, mature in 2 years</td>
<td>marketed as red oak, furniture, flooring, boxes, timbers, handles, implements</td>
</tr>
<tr>
<td>Northern Red Oak</td>
<td>4-9&quot; long, 3-6&quot; wide, alternate; elliptical, 7-11 shallow, wavy lobes</td>
<td>dark gray to blackish, furrowed into scaly ridges, inner bark is reddish</td>
<td>.5-1&quot; acorns, long, egg-shaped, less than one-third enclosed by broad cup</td>
<td>most important red oak lumber species, flooring, furniture</td>
</tr>
<tr>
<td>Blackjack Oak</td>
<td>alternate; 2.5-5&quot; long, 2-4&quot; wide, slightly triangular or broadly obovate, 3 broad lobes</td>
<td>blackish, thick, rough, deeply furrowed into broad, almost square plates</td>
<td>.5+ - .75&quot; acorns, elliptical, end in stout point, thick, top-shaped up of rusty brown</td>
<td>railroad cross-ties, firewood, charcoal</td>
</tr>
</tbody>
</table>

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<table>
<thead>
<tr>
<th><strong>American Sycamore</strong></th>
<th>3-4 lobed, divided by broad sinuses, 4-7 inches long and broad, broadly ovate, wavy edges, scattered long teeth</th>
<th>whitish and mottled, smooth, peeling off upper parts of tree and branches in large thin flakes</th>
<th>1 in. in diameter, 1 brown ball on long stalk, composed of many narrow nutlets with hair tufts</th>
<th>furniture, millwork, flooring, butcher blocks, handles, containers, pulpwood, particleboard, fiberboard</th>
</tr>
</thead>
<tbody>
<tr>
<td>Height: 60-100+ feet, Diameter: 2-4 ft. (up to 10 ft.)</td>
<td>3-6 inches long and wide, distinctive shape with broad base and tip</td>
<td>dark gray, becoming thick and deeply furrowed</td>
<td>2.5-3 in. long; conelike; light brown; composed of many overlapping nutlets 1-1.5 in. long</td>
<td>lumber, boxes, veneer, pulpwood, crates, siding, musical instruments, furniture, cabinetwork</td>
</tr>
<tr>
<td><strong>Yellow Poplar</strong></td>
<td>alternate in 2 rows, 3-6 in. long 1-3 in. wide, elliptical, long-pointed, doubly saw-toothed</td>
<td>light gray; deeply furrowed into broad, forking, scaly ridges</td>
<td>up to .5 in. long, elliptical flat, 1-seeded samaras, wing hairy on edges, deeply notched; on long stalk</td>
<td>shade tree, furniture, containers, dairy and poultry supplies, veneer, boxes, crates, baskets</td>
</tr>
<tr>
<td>Height: 80-120 feet, Diameter: 2-3+ feet</td>
<td>alternate, 2-5 in. long, 1.25-2&quot; wide, elliptical, finely saw-toothed, with curved or blunt teeth</td>
<td>dark gray; smooth with horizontal lines; irregularly fissured and scaly, exposing reddish-brown inner bark</td>
<td>a small cherry; dark red turning blackish, elliptical stone, slightly bitter, juicy, edible pulp</td>
<td>furniture, paneling, veneer, professional and scientific instruments, handles, toys, jelly, syrup &amp; cough medicine</td>
</tr>
<tr>
<td><strong>American Elm</strong></td>
<td>3-6 inches long and wide, distinctive shape with broad base and tip</td>
<td>dark gray, becoming thick and deeply furrowed</td>
<td>2.5-3 in. long; conelike; light brown; composed of many overlapping nutlets 1-1.5 in. long</td>
<td>lumber, boxes, veneer, pulpwood, crates, siding, musical instruments, furniture, cabinetwork</td>
</tr>
<tr>
<td>Height: 100 feet, Diameter: 4+ feet</td>
<td>alternate in 2 rows, 3-6 in. long 1-3 in. wide, elliptical, long-pointed, doubly saw-toothed</td>
<td>light gray; deeply furrowed into broad, forking, scaly ridges</td>
<td>up to .5 in. long, elliptical flat, 1-seeded samaras, wing hairy on edges, deeply notched; on long stalk</td>
<td>shade tree, furniture, containers, dairy and poultry supplies, veneer, boxes, crates, baskets</td>
</tr>
<tr>
<td><strong>Black Cherry</strong></td>
<td>alternate, 2-5 in. long, 1.25-2&quot; wide, elliptical, finely saw- toothed, with curved or blunt teeth</td>
<td>dark gray; smooth with horizontal lines; irregularly fissured and scaly, exposing reddish-brown inner bark</td>
<td>a small cherry; dark red turning blackish, elliptical stone, slightly bitter, juicy, edible pulp</td>
<td>furniture, paneling, veneer, professional and scientific instruments, handles, toys, jelly, syrup &amp; cough medicine</td>
</tr>
<tr>
<td>Height: 80 feet, Diameter: 2 feet</td>
<td>alternate in 2 rows, 3-6 in. long 1-3 in. wide, elliptical, long-pointed, doubly saw-toothed</td>
<td>light gray; deeply furrowed into broad, forking, scaly ridges</td>
<td>up to .5 in. long, elliptical flat, 1-seeded samaras, wing hairy on edges, deeply notched; on long stalk</td>
<td>shade tree, furniture, containers, dairy and poultry supplies, veneer, boxes, crates, baskets</td>
</tr>
<tr>
<td><strong>American Sycamore</strong></td>
<td>3-4 lobed, divided by broad sinuses, 4-7 inches long and broad, broadly ovate, wavy edges, scattered long teeth</td>
<td>whitish and mottled, smooth, peeling off upper parts of tree and branches in large thin flakes</td>
<td>1 in. in diameter, 1 brown ball on long stalk, composed of many narrow nutlets with hair tufts</td>
<td>furniture, millwork, flooring, butcher blocks, handles, containers, pulpwood, particleboard, fiberboard</td>
</tr>
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<td>Height: 60-100+ feet, Diameter: 2-4 ft. (up to 10 ft.)</td>
<td>3-6 inches long and wide, distinctive shape with broad base and tip</td>
<td>dark gray, becoming thick and deeply furrowed</td>
<td>2.5-3 in. long; conelike; light brown; composed of many overlapping nutlets 1-1.5 in. long</td>
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</tr>
<tr>
<td><strong>Yellow Poplar</strong></td>
<td>alternate in 2 rows, 3-6 in. long 1-3 in. wide, elliptical, long-pointed, doubly saw-toothed</td>
<td>light gray; deeply furrowed into broad, forking, scaly ridges</td>
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Thoreau

**Forestry** – “In wilderness is the preservation of the world” Henry David

**Threats to Forests**

Human activities are one major threat to our forests. Man has cut, cleared, and burned forest for agricultural land, development, highways, and for products. Over 95% of the forests that once covered the U.S. have been cut. Our industrialized, heavily fossil fuel dependent activities produce air pollution, a major threat to forests in some parts of the country. Acid rain and deposition cause leaf damage and acidification of the soil resulting in weakened, less resistant trees. Damage to the trees is mainly through their foliage, and conifers are affected more than hardwoods. Sulfur dioxide, nitrogen oxides, ozone, chlorine, and fluoride are known defoliators. Any damage to a tree’s bark during logging or other human activities, opens the tree to infestation by insects or disease. Man is also often the cause of forest fires.

Forests have many natural threats, including storms, ice, fire, disease, fungi, and insects. Some of these threats are natural but the cause of some can be traced back to man. Many of the organisms that threaten forests today are alien, or exotic, species. Alien species are organisms that are brought into an area, where they do not naturally exist, by people. These new organisms have no natural predators, often reproduce quickly, and compete with the existing organisms for all the things necessary for life. The organisms native to the area, including trees, have no natural defenses against these new species. Without adaptations to protect themselves, native species are prone to attack by exotic species. The gypsy moth, chestnut blight, and Dutch elm disease are examples of destructive exotic species introduced to American forests. While careless actions by man cause many wildfires, some are caused by lightning associated with storms. Ice and snow, heavy winds of storms, and drought can damage or weaken trees, making them more susceptible to attack by insects or disease.

**Forest Insects**

**Borers – Bark Beetles**

These insects bore, or chew, their way through the outer and inner bark destroying the cambium and phloem, girdling the tree, and introducing destructive blue stain fungi. The bark beetles are the most destructive of all forest insects.

**The IPS Beetle**

Trees that are weakened, dying, or recently fallen are susceptible to attack by the Ips beetle. It is often the first beetle to attack a pine forest weakened by a drought. Ips beetles only attack pine trees. They attack sixteen species of pines, eleven of which are native to the southern United States. North Carolina pines that can be affected by the Ips beetle include the eastern white pine, loblolly pine, longleaf pine, pitch pine, and Virginia pine.

An attack of the Ips beetle on a pine is usually not noticed until long after the beetles have started to damage the tree. The first noticeable sign of the Ips beetle is that the needles of the trees start to turn yellow or red in color. The bark of the tree may also have small holes, about the size of a BB, that are surrounded by red or yellow dust. The needles change colors and die because the beetles and blue stain fungus introduced into the tree by the beetles cut off the supply of water and nutrients to the crown of the tree and its needles. Another sign of the Ips beetle is...
patterns, or galleries, on the inside side of bark that look like the letters Y or H. These patterns are actually the places where the beetles laid their eggs.

The best way to prevent Ips beetle attacks is to limit the number of weakened, dead, or dying trees in an area. Another step that can be taken to reduce the chance of infestation is to remove fallen and infected trees as soon as possible and to minimize the damage done during logging. It is also important to try to limit the damage done to pine trees in everyday life. Healthy trees can often resist attack.

**Southern Pine Beetle**
The southern pine beetle is about the size of a single grain of rice, but it is the most damaging insect, causes thousands of dollars of damage to southern pines each year. It mainly feeds on the loblolly, shortleaf, pitch, and Virginia pines, but it will feed on any pine tree that is dead, dying, or weakened by some other force of nature.

Very often, pine trees are attacked by more than one type of beetle at the same time. The southern pine beetle, Ips beetle, and black turpentine beetles may all attack the same tree. Each beetle attacks a different section of the tree. The southern pine beetle is usually found is the lower portion of the tree just above the stump while the Ips beetle are usually found higher up on the tree's trunk.

Sometimes the southern pine beetle is the only beetle that is found in a pine tree. It can kill a pine tree by itself. It does this by boring through the bark of the tree and making galleries, or paths, which look like the letter S. Females lay their eggs on the sides of these galleries. When their eggs hatch, the larvae eat through the cambium, or living part, of the tree. This stops the flow of water and nutrients to other parts of the tree, killing it. The adult beetles also eat the cambium of the tree. Blue stain fungus, which lives inside the beetle, is excreted in its waste and hastens the tree’s death by also blocking water and nutrient intake.

The first signs of an attack are small lumps of pitch on the outside of a pine tree. These lumps are about the same size as a kernel of popcorn, and are called pitch tubes. When the beetle bores into the bark, the tree produces pitch to try to keep it out. Healthy trees are sometimes successful in keeping the invading beetles out. Weakened trees, on the other hand, cannot produce enough pitch to keep the beetles out. The next symptom is the small S shape paths, or galleries, found on the inside of the bark. The last and most noticeable symptom is the needles changing from a healthy green color to yellow, red, or brown in color. Once the needles of the tree have started to change colors, there is little that can be done to save the tree from death.

The same methods of preventing attacks from the Ips beetles can also be used to prevent attacks from the southern pine beetles.

**Black Turpentine Beetle**
The turpentine beetle is the largest beetle pest. They are usually about a fourth of an inch in length but can be up to a half of an inch in length. It is the largest but it causes less damage than the Ips and southern pine beetles, although in recent years,
it has become a more serious forest pest. Stress on trees, natural and man-made, has increased tree susceptibility. This beetle is typically less destructive, because smaller groups of beetles attack smaller groups of trees each year. They tend to live in and attack the lower portion of a tree, and will sometimes even make their homes in tree stumps that have just been cut. Trees that are weakened or dead and dying are the ones that are typically attacked. The signs of an attack are similar to those of an attack by the Ips or southern pine beetle. The distinguishing mark of the turpentine beetle is that its galleries do not look like a letter. The galleries of a turpentine beetle are usually just wandering paths that take on no particular shape. They can also be distinguished because they attack only the bottom portion of the tree. The pitch tubes of the turpentine beetle are often shaped like a human thumb.

Methods of control include spraying insecticide or, more preferable, logging the infected trees. Natural predator insects also help control populations.

**Leaf Eaters and Tip Feeders**
These insects eat all or part of the foliage or cause malformations or discoloration by sucking the sap and those that feed on the growing tip.

**Gypsy Moth**
The gypsy moth is an exotic species that mainly attacks deciduous, or hardwood, trees. First introduced in the United States in 1869 by a French scientist living in Massachusetts, it continues to spread south and west.

The gypsy moth is the most destructive defoliator in the U.S. It is only harmful to trees during the larval, or caterpillar, stage of its life. This stage begins as leaves start to emerge. When they have eaten all the leaves from their host tree, they crawl away and find another tree.

The mature moth lays its eggs on or near hardwood trees so the new larvae will have an immediate food source when they hatch. The adult gypsy moth dies shortly after it has laid its eggs.

Tree species most commonly attacked by the gypsy moth larvae are oaks, apple, sweetgum, speckled alder, basswood, gray and white birch, poplar, willow, and hawthorn; but hungry larvae will eat leaves of most other trees including conifers. Some trees and shrubs appear to be resistant to the gypsy moth larvae, including ash, yellow poplar, sycamore, butternut, black walnut, catalpa, flowering dogwood, balsam fir, red cedar, American holly, mountain laurel, rhododendron, and arborvitae.

Gypsy moths usually cannot kill a healthy tree in one year. The real danger to trees happens when they are attacked by gypsy moths several years in a row. Trees that are weakened by some other force and then attacked by gypsy moths, which destroy more than half of its leaves, can be killed in just one year's time.

Some things that can be done to help control the gypsy moth population and limit the number of trees that they harm are planting a variety of trees, including some that the gypsy moth will not attack; reducing sites where larvae can pupate, such as
old cans, bottles, boxes, and tires and destroying the moth eggs. Pesticides can also be used to help limit existing populations. Maintaining the overall health of trees in an area is one of the most important measures to help limit the effects of an attack by the gypsy moth.

**Asian Gypsy Moth**
This strain of gypsy moth was introduced aboard a military cargo ship into Wilmington, N.C. This version of the gypsy moth is perhaps a greater threat to forests, because they are very good flyers and may spread quickly.

**Balsam Wooly Adelgid**
This sap sucking, tip-feeding insect is primarily a concern for North Carolina’s Christmas tree growers.

**Tent Caterpillars**
These insects often cause much defoliation of hardwoods, but are not presently a very injurious forest pest in the South. Eastern tent caterpillars in the spring and fall web worms in the fall.

**Pine Sawfly**
The caterpillars of the sawfly feed on pine needles leaving just stubs. The trees may be stunted or deformed, and serious infestations may kill young pines.

**Diseases**
Tree disease is defined as sustained structural and functional damage of living tissue, which may cause the tree’s death. Forest diseases can be caused by aspects of the physical environment such as the weather, air pollution, poor soil, or damage by insects, animals, or man. They may also be caused by viruses, fungi, bacteria, or parasitic plants. However, most major forest tree diseases are caused by fungi. Damage from such diseases is usually not seen until they have seriously impacted the tree. These silent killers destroy more timber each year than forest fires.

**Annosus Root Rot**
This disease is caused by a fungus and attacks a wide range of conifers. Red cedar is especially prone to attack. This disease starts when the fungi spores enter the stump left after a tree has been cut. From there, the fungus works its way down to the roots. The disease is spread as the roots of infected trees come in contact with the roots of other trees.

**Red Heart or Red Ring Rot**
This fungus attacks and decays the heartwood of the tree. It can attack almost all conifers and often infects long-leaf pines. Long leaf pine trees infected by red heart disease provide habitat for one of North Carolina’s endangered species, the red cockaded woodpecker. This disease is most damaging in the south in mature and over mature pines. The best way to prevent infestation is to reduce wounding of trees from logging, fire, or other actions and to cut when tree matures.

**Fusiform Rust**
Another group of forest diseases that cause many problems for trees each year is
the rusts, a type of fungus. Rusts usually affect the stem, the trunk and the branches of the tree and cause **galls**, or swollen growths. Fungal galls usually have a rougher outer covering and may look like they are covered by warts. Insect galls on the other hand, are usually smaller and have a smooth outer covering. Rusts are a problem for coniferous trees. It mostly affects loblolly and slash pines. Trees with fungal galls should be removed as soon as possible to stop the fungus from spreading. Fusiform Rust is the main one in loblolly pine. Trees with insect galls do not necessarily have to be removed, because they generally pose no immediate threat to the other trees.

**Heart Rot**

This fungus is the single most damaging disease to merchantable hardwood timber.

**Oak Wilt**

A stem disease that attacks most oak species, particularly the red oaks, wilt causes the tree’s leaves to die from the edges inward. Defoliation progresses from the outer limbs, inward and down.

Today, most fungal diseases don't create the threat of extinction, but this has not always been the case. At one time the American chestnut was found throughout the southern United States. In 1900, a fungal disease, known as chestnut blight, was accidentally introduced to the US from Asia. Within thirty years, chestnut blight had killed all of the chestnut trees.

**Fire**

In unmanaged forests or where fire has been suppressed for long periods, wildfires can be devastating. Wildfires, however, are not always a bad thing. Fire is necessary for many ecosystems to survive. Some forests are “fire-dependent ecosystems.” One such ecosystem, found in North Carolina, is the long leaf pine forest. Organisms found in fire dependent ecosystems often have special adaptations that enable them to survive the fire and/or use the fire to their advantage. The long leaf pine is a good example of an organism that is well adapted to wildfires. In the past, fire has burned the long leaf forest, on average, once every three to five years. To survive fire, the long leaf pine has a unusual growth pattern. During the first few years of its life, known as the “grass stage,” it doesn’t appear to be growing. It looks like a small clump of needles growing from the ground. The actual tip of the tree is not visible, because it is surrounded by dense needles. The real growth is going on underground. It sends a thick and sturdy tap root deep down into the soil. This large root provides all the water and nutrients the young tree needs and firmly anchors it in place. If a fire burns through the area during this stage, it may burn up the needles that protect the tip, but rarely burns the actual tip of the tree. The burned needles are quickly regrown by the young tree. Usually after seven or eight years, noticeable growth begins. The long leaf may grow three to four feet a year once it begins this stage of its life, known as the pole stage. The tree is tall enough after one year's growth for its growth tip to escape wildfires, provided there is not much fuel on the forest floor. Another adaptation is the thick bark of the mature tree, which protects the inner, living tissue from harm.
The long leaf pine forest is dependent on fire for its existence. The fires stop natural succession by killing young turkey, blackjack, and post oak that would eventually prevent the growing long leaf pines from receiving enough sunlight. The seeds of the long leaf pine need cleared ground to reach the soil and germinate. The fire clears the forest floor and returns nutrients to the soil, favoring the tree’s reproductive success. Some other pine species are also adapted to fire. The cones of the pond pine will open and drop their seeds only in the heat created by fires.

**Forest Management**
Approximately 25% of the world’s forests are currently managed for wood production. There are two main ways to manage a forest: even-aged management and uneven-aged management. In even-aged management, the trees are all the same age. Even-aged management is a common practice when a forest is going to be used mainly for commercial forestry. This practice is sometimes called tree farming. In most cases only one or two species of fast growing trees are grown in these areas. To start an even-aged forest the original forest must first be cleared. This eliminates the diversity that was once found in an area and alters vital and important wildlife habitat. Even-aged stands of forest are more susceptible to disease because all of the trees are the same age and species. In even-aged forest all of the trees are generally clear-cut from time to time. They are then replanted and then cleared again after a set amount of years. Even-aged management uses the forest mainly for economics (lumber) and gives little attention to its ecological importance (the services in nature they provide). However, this type of forest farming keeps the stand in an early successional stage. This stage is a preferred area for deer, rabbits, songbirds and quail.

Uneven-aged management involves growing a variety of trees of different ages and species in the same area. It encourages the natural regeneration of the forests. Uneven-aged management capitalizes on the ecological benefits of the forest instead of focusing solely on the economic benefits. In uneven-aged management, mature and undesirable trees are cut in small patches in ways that benefit the overall health of the forest.

**Controlling Infestation by Insects and Disease**
The study, detection, and control of pests and diseases are important parts of forest management. Forest entomology is the study of insects that attack forest trees. Forest pathology is the study of diseases that affect forest trees. Both are parts of successful forest management to produce marketable timber and lumber. Healthy trees are essential to a profitable harvest.

**Integrated Pest Management**
Pest management is particularly important in the more vulnerable even-aged stands of pine plantations and Christmas tree farms. Cooperative extension agents and foresters recommend to these owners the use of integrated pest management, or IPM. Integrated pest management is just that, the use of integrated or multiple methods to prevent or manage the problem. Different methods of control, which take advantage of technology and knowledge of the pest’s life cycle and habits, are used alone or in combination.
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Chemical – The use of chemical pesticides or insecticides to prevent or control infestation.
- Biological – The use of natural predators to control populations, or use of pheromones to disrupt the reproductive cycle of pests.
- Mechanical (physical) – The use of physical methods, such as traps, barriers, destruction of eggs or pupa, or removal of infested trees, to control pest infestations.
- Cultural – Planting multiple varieties rather than one species or species less prone to attack, varying the time of planting and harvesting, and activities to improve the health of existing trees.
- Regulatory – Laws and regulations regarding the transport or inspection of any plant materials, vegetables, or fruits entering areas; and the strict enforcement of those regulations. Some states, such as California, strictly regulate the flow of any plant material into the state, even in an individual’s vehicle.

Forestry (Silviculture)
The term silviculture refers to managing a stand of trees for a specific purpose and to meet certain needs of an area or wishes of the individual who owns the stand. To accomplish this, a management plan with management objectives is the first step. Things that may be considered in a forest management plan are wildlife habitat, protection of the watershed, recreational uses, aesthetic value, and the production of timber. Silvicultural techniques vary from one stand to another due to the needs of different stands. Some management techniques are listed in the following silviculture practices.

Silvicultural practices include:
- Application of various treatments for clearing forest floor:
  ~ prescribed burns
  ~ spraying of herbicides and pesticides
  ~ cuttings
- Intermediate Cutting – the main objectives are:
  ~ improvement of the stand, removal of inferior trees
  ~ manipulation or regulation of tree or stand growth
  ~ early financial return
  ~ reduction of conditions that favor insect pests or disease
  ~ creating conditions favorable to reproduction

Methods used include:
* Thinning to improve stand growth by reducing competition
* Intermediate Cuttings including salvage cutting and pruning

- Liberation Cuttings
  ~ free saplings from competition of older, over-topping trees

- Harvest Cuttings:
  ~ Clear Cutting
  ~ Seed Tree Cutting
  ~ Shelterwood Cutting
  ~ Selection Cutting

- Planting or Regeneration
Tree Harvesting Techniques
There are many techniques that can be used to harvest trees. One step common to all is the building of a road, to get the people or machines in to cut the timber and to get the timber out. The construction of the road can cause many problems. It increases the erosion and the amount of sediment carried into local streams. It destroys part of the habitat, and creates habitat fragmentation. Logging roads in stands of timber may make the area more vulnerable to disease and/or exotic species. They also open the forest to more use by humans, which may cause destructive fires.

Erosion can be a major problem. In fact, logging roads in some steep areas in the mountains of North Carolina can cause the loss of up to 200 tons of soil per acre of roadway during the first year after their construction. A forestry management practice to prevent water pollution by sediment is leaving streamside management zones (SMZ) as a buffer. These areas of various types of vegetation trap sediment and pollutants preventing them from entering the streams and rivers.

Habitat fragmentation is a big problem in some areas. The dividing of habitats into smaller and smaller pieces results in problems for some specialized species or species requiring large tracts of land. Fragmentation may limit access to needed aspects of their habitats such as food, shelter, or breeding grounds.

Clear-cutting
Clear-cutting is the least expensive method for harvesting trees. It is usually used to harvest even-aged stands. In clear-cutting all the trees are removed from the area in one single cutting. After the trees are cut the area is usually reforested. This can happen one of two ways: 1) naturally by seeds dispersed during the cut or from nearby trees or 2) by foresters putting seeds in the area or planting seedlings grown in a nursery. Like all harvesting methods, it has benefits and drawbacks. Some of its benefits include: an increase in overall timber yield, trees that are genetically stronger or more well suited to the site may be planted, requires less skill and planning; and provides timber companies with the most money in the shortest amount of time. One other positive aspect of clear-cutting is that it requires very little road building. Some negative aspects of clear-cutting include ugly patches of forest, habitat fragmentation, altered wildlife habitat – that benefits early successional species, increased rate of erosion, and increased amount of sediment in the water causing an overall decrease in the water quality. In some cases, clear-cutting makes surrounding areas more prone to flooding.

In certain situations clear-cutting may be the best method of tree harvesting. An example would be stands that are full of mature or over mature trees or species that are not desirable. Clear-cutting could then be used to remove those trees and replace them with trees that are better suited to the site, more desirable, and more profitable for the landowner.

Seed tree cutting is a type of clear cutting. All of the trees are cut except for some good quality, seed bearing trees. These trees are left to reseed and repopulate the area, allowing for more natural succession to take place. Seed tree cutting is usually
used with trees that bear seed often and have the ability to disperse their seeds over a wide area. Foresters leave between four and ten large trees per acre. In most cases these trees are able to repopulate the forest in a reasonable amount of time.

Another type of clear-cutting is known as **strip cutting**. In strip cutting, a strip of trees is cut along the contour of the land. The strip is narrow enough so that natural regeneration will happen after a few years. After regeneration has occurred, another narrow strip in the stand is clear-cut and the process cycles through again. Strip cutting allows for a stand to be clear-cut over a few decades. It causes less destruction of habitat for wildlife, lessens the amount of erosion and water pollution, and does not leave a large, ugly scar like regular clear cutting.

A controversial type of clear-cutting is **whole tree harvesting**. In **tub grinding** whole tree harvesting, machines cut the tree at ground level or sometimes even uproot the entire tree. The tree is then cut into wood chips by a machine. This method is only used for site preparation for development or construction, and it causes severe ecological damage. No large roots remain to hold the soil in place, greatly increasing erosion. Dead and fallen logs are also removed, causing the loss of many wildlife habitats and decreasing the amount of nutrients returned to the soil and available for use by plants that survive. The forestry practice of whole tree chipping uses only the live wood cut off at ground level. It does not remove dead wood or forest litter, thus it does not result in the same environmental damage.

**Selective Cutting**

Unlike clear-cutting, selective cutting involves only removing certain trees from an area. Selective cutting is generally used in uneven-aged stands. It involves cutting individual or small groups of large, mature trees in order to provide better conditions for the remaining trees. It creates small gaps in the canopy that allow for more sunlight to reach the forest floor and thus encourages the growth of other trees. After a few years have passed, more trees can be cut.

Selective cutting is beneficial in many ways, because it allows for the continued growth of the uneven-aged stand. It promotes growth of younger trees while reducing crowding. It encourages the natural regrowth of native plants in the forest. Selective cutting causes less soil erosion and decreases the amount of damage done by wind while providing a more diverse habitat for wildlife. Some negative aspects of selective cutting are: it produces less money than other harvesting methods, it requires planning and skill, it can cause damage to the remaining trees, and it requires more frequent human disturbance.

**Shelter-wood cutting** is one type of selective cutting. Shelter wood cutting harvests the mature trees in an area over a period of time in several cuttings. It usually occurs over a period of ten years and consists of two or three cuts spaced at least two years apart. The first cut removes the tallest trees, as well as any smaller trees that are damaged or diseased. The removal of these trees allows for more sunlight to reach the forest floor and thus causes the growth of new seedlings and other plants, as well as improving the health of the forest. A few years later, the second cut is made. By this time, many new trees have begun to grow. More of
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The canopy trees are harvested during this cut; however, some large trees are left to protect the young trees. Several years later, the final cut is made where all of the remaining mature trees are harvested. The younger trees in the stand are then left to grow as an even-aged stand.

One type of selective cutting, which is not an ecologically good harvesting practice, is **high grading or creaming**. High grading involves harvesting only the most valuable trees in a stand. This method removes the best quality trees, leaving genetically inferior stock to repopulate the area. It is commonly used in area with a tropical forest. It is no longer a common practice in the U.S. High grading usually ends up injuring one-third to two-thirds of the other trees in the forest. Damage can be caused by the equipment used to harvest and remove larger trees or by falling trees. Some of the injured trees are knocked down. Others have branches and/or bark removed. These injuries make the remaining trees more susceptible to insects and diseases.
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Reforestation

Reforestation is the replanting of trees after harvesting. Today, reforestation has become a fairly common practice. Two methods can be used: planting seedlings or allowing for natural regeneration. Reforestation by planting seedling is usually done for stands of conifers, while hardwoods are left to natural seed dispersal and sprouting regeneration. Conifers are planted because they grow quickly and can grow in poorer quality soils. Most reforestation uses nursery stock and allows for genetically stronger trees to be grown. These species are generally stronger and more resistant to disease and pests. Reforestation produces even-aged stands of trees.

Forest Management and the Private land owner

Most of the forested land in North Carolina is owned privately, and it is important for these landowners to manage their forests. Forested, private land can be managed for whatever purpose the owner would like. It can be managed for recreation, wildlife, aesthetic value, timber production and sales, or a variety of purposes.

The first step in managing is consulting a professional forester. Foresters will help the owner determine the best way to manage the forest to suit their purposes and then develop a management plan.

If the landowner wants to manage the forest for timber harvest and sale, the following steps should be taken

• Use a forester- Use a forester to help you determine which type of harvest is best to use to meet your objectives. Studies have shown that landowners who use a forester to help plan their harvest get more money for their timber.

• Know what you are selling- Landowners should know the timber that they are selling well. They should know the tree species, amount of timber available, what the cut timber will be used for (pulpwood, saw logs, etc), and the current market value of the timber.

• Plan for reforestation- this is a very important step, if the plan is to maintain the land as a forest. The planned type of reforestation may have an impact on the timing of the timber harvest. If the landowner does not plan to reforest the land, then a plan should be developed to control the increased erosion caused by some methods of timber harvest.

• Identify the method of timber harvest- there are many ways that the timber can be harvested. The landowner should have basic knowledge about these and, with the help of a forester, determine which method is best for their wants and needs.
Management for Wildlife and/or Recreation
There are several things a landowner may do to manage their land which will increase the amount of wildlife and make it more suitable for recreational uses. Many times, this can be along with a timber harvest. Some methods to encourage wildlife in an area during and after a harvest are to:

- Leave snags (dead trees that are still standing) and some large den trees for wildlife use.
- Think about managing the forest as a mixed (coniferous and deciduous) forest to increase wildlife.
- Leave a corridor (or uncut strip of trees) connecting cut area for the use of the wildlife.
- Leave buffer strips along any creeks, rivers, or streams that flow through the area. (This is required by law.)
- Make the boundaries of the timber harvest into an irregular shape. This will increase the overall area of the edge and thus increase the "edge effect" for wildlife.

Protecting Forested Land
There are some practices that can be done to protect the overall value and health of private forestland, no matter what the ultimate management goal is. These practices include:

- Thinning over-crowded stands of both hardwood and softwood trees. This improves the overall health of the stand by encouraging growth, decreasing the risk of insect attacks and disease, and decreasing the amount of competition for sunlight, water, and nutrients from the soil.
- If an insect, such as the southern pine beetle, attacks a tree or small stand of trees, the infested tree(s) should be cut down and completely removed from the area as soon as possible to prevent further infestation.
- Strips of hardwood trees planted in pine forest can act as buffer strips and can be a way to prevent the spread of bark beetle invasions.
- Match the type of soil in an area to the type of tree that will grow well in that soil. Sites planted with trees poorly suited to the soils can be more susceptible to various diseases, such as rusts.
- Conduct prescribed burns every three to five years. This will reduce the danger of a wildfire because it reduces the amount of fuel available. Prescribed burns can also help control some diseases, such as fusiform rust and can benefit wildlife.

Forestry Best Management Practices

Water resources and the roles of forests in stabilizing soils and protecting watersheds are widely recognized. Any time a forest is disturbed there is potential for increased erosion and harm to water bodies. The use of best management practices (BMPs) in forest management helps minimize or eliminate these risks.
Best management practices for forestry include:

~ Streamside management zones (SMZs) – Vegetation along streams to slow and spread surface water flow and to trap and filter suspended sediments.

~ Road BMPs to protect water quality – water control structures
  - Water turnouts to divert water from road surfaces
  - Crossroad drainage by culvert to transfer water across or under roads
  - Broad-based drainage dips to slow and move water off the road
  - Rolling dips to slow water flow on roads or skid trails
  - Water bars to move water off roads into undisturbed areas

~ Planning and use of as few stream crossings as possible, good drainage from crossings diverting water into undisturbed areas, and removal of all temporary stream crossings after harvest.

~ Planting permanent vegetative cover along roads and all openings created

Minimizing Wildfire Risk

Fire has been a natural part of our forests’ history. Lightning ignited fires that burned and were controlled only by nature. Fire resistant species survived in frequently burned areas while others died out. Some of our forests adapted into fire dependent ecosystems, requiring periodic fires to survive. Fire is beneficial to many wildlife species. It opens up areas of the forest to new growth, increases grazing areas, and starts new succession. The devastating fires that burned Yellowstone National Park are an example. They left ugly views, but park rangers and biologists report that most species, except the moose, have benefited and increased in numbers.

Throughout history, man has made use of fire and has been a part of the wildfire problem. Native Indians used fire to clear land and to improve hunting. Settlers used fire to clear land for settlements and agriculture. Today, careless actions by man, such as burning trash, discarded cigarettes, and campfires, cause many wildfires.

Wildfires are influenced by three major factors, which determine the risk, spread, and behavior of the fire:

- Weather
- Topography
- Vegetation
Weather
Wind, temperature, rainfall, relative humidity, and stability of the atmosphere impact fire behavior. High or gusty winds, low humidity, drought, and high temperatures lead to rapidly spreading wildfires. Winds also dry fuels on the forest floor increasing the chance of fires and providing good tinder for any ignited fire.

Topography
Steep slopes increase winds, expose fuels to more drying, and can speed the spread of wildfire. On areas with moderate slopes (40% incline), fire can spread twice as quickly. Fire can spread four times faster on very steep slopes (70% incline). Topography also affects the direction fires spread. Narrow areas, drafts, act like chimneys moving the fire rapidly through the area.

Vegetation
Ground fuels are vegetation close to or built up on the forest floor. They include forest litter, such as leaves or pine needles, limbs, downed logs; and low growing plants, such as weeds, shrubs, and young trees. These fuels are the primary means for the spread of wildfire. The build-up of ground fuels poses a serious threat of wildfire. Fires that begin in forests with a heavy accumulation of fuels spread rapidly and often move up through shrubs, vines, and small trees to the tops, or crowns, of the trees. The fuels that allow the upward spread to the crowns are called ladder-fuels, and the resulting crown fires are devastating to the forest.

Wildfires can be classified into several categories.
- Surface – fires that burn the litter on the forest floor: leaves, branches, and other debris.
- Ground – fires that burn close to or beneath the forest floor, burning the organic material on and within the soil, such as peat.
- Crown – fires that burn the tops, or crowns, of trees often destroying the tree, and are difficult to control.

While fire is a threat to homes and the timber industry, it is a very effective tool for foresters. A managed fire, or prescribed fire, can be used for many purposes. Burns can reduce the risk of wildfire by preventing the build up of ground fuels. They can be used to kill weakened, diseased, or undesirable trees. Prescribed burns can be used to stimulate regeneration in the forest, maintain a fire dependent

Ladder Fuels and Recommended separation of ladder fuels
N.C. Cooperative Extension Service

Types of Forest Fuels
Prescribed fire (prescribed burn)- a managed fire, contained to a set area, intentionally set by man for a specific purpose. A fire management tool.
ecosystem, and create openings for wildlife habitat. Fire is also used to fight wildfires. Backfires are intentionally set to burn toward the fire, eliminate fuel from its path, and create a firebreak to slow or stop the wildfire.

Management Practices to Minimize Wildfire Risk

~Thinning – The cutting or removal of trees from a stand to control the number, quality, and/or distribution of remaining trees. This lowers wildfire risk by reducing the density of the stand and the woody debris that accumulates on the forest floor.

~Pruning – The removal of low-hanging vegetation to prevent the risk of ladder fuels reaching the crown.

~Fuel Reduction Burning – Prescribed burns to reduce the level of dangerous, combustible fuel buildup on the forest floor. Prescribed burns are typically conducted in pine forests rather than hardwood forests.

~Firebreaks – The development of a network of firebreaks, natural and man-made to reduce the risk of wildfires spreading. These may also enhance wildlife habitat by providing ecotones and improve access to the property. Firebreaks should be at least 10-12 feet wide. Existing streams, logging roads, skid trails, and cultivated fields serve as firebreaks. Mowing, brush chopping, and disking can also be used to create firebreaks. All overhanging brush and vines should be removed from firebreaks.

Policy

Shortly after the creation of the U.S. Forest Service, devastating fires in the west helped initiate a policy of total fire suppression. In time, the slogan “only you can prevent forest fires” and Smoky the bear became a highly recognized part of the public awareness campaign for fire prevention. It was later realized that the practice of total suppression may not always be the best management practice. This policy may have added to the intensity and devastation of many wildfires. Today the forest service uses prescribed burns to clear areas of dangerous fuel buildup and allows some wildfires to burn uncontrolled in national parks and wilderness areas. We have come to recognize that fire is a natural, even essential, part of some ecosystems.

Forest Conservation

Almost a quarter of the commercial forests in the United States are found within the 156 national forests. This land is managed by the U.S. Forest Service. Timber companies are allowed to harvest trees, and the Forest Service receives part of the money for its budget from these timber sells. Reforestation of these areas insures the continued supply of timber for the nation and the conservation of our forests for their ecological benefits. The U.S. Forest Service and National Parks Service employ various methods to maintain, protect, and preserve our forest resources for future generations.
Forestry Measurements

Forestry is more than just trees. Part of forestry is the industrial aspect of it. We depend on the forests for many of the things we use everyday, and thus, the timber industry is very important. Like any other discipline, forestry has its own unique set of measurements that will be discussed in this section.

The first important measurement to an individual is to know one's own pacing. Pacing involves counting the number of steps it takes you to travel a certain distance. In forestry this distance is 66 feet. To determine your pace use a tape measure to measure out 66 feet. Then, count the number of steps it takes you to walk that distance. Every time your right foot hits the ground is equal to one step. Do this several times to make sure you get the same results each time. Being able to pace off 66 feet accurately is important and plays a part in many of the other forestry measurements that you will make.

In forestry, the standard unit for measuring distance is the chain. A chain is equal to 66 feet. In the past, surveyors and foresters actually hauled 66-foot chains around with them to measure properties. During this time, measurements were made in chains and links. Chains are important because many forestry tools are designed to be used at a distance of one chain. These tools will only provide correct and accurate measurements when used at that distance. Some other useful chain measurements are eighty chains equal one mile and ten square chains equal one acre.

Tree Diameter

A measurement of the diameter of a tree can be very useful in determining tree growth and overall health of a tree. Tools that are commonly used to measure diameter are a diameter tape (or d-tape) and a Biltmore stick. Diameter is measured at 4 and 1/2 feet, or diameter at breast height (DBH). Diameter is measured on the uphill side of the tree. It is usually measured to the nearest tenth of an inch when using a d-tape. The diameter tape is calibrated so that you are measuring diameter while actually placing the tape around the circumference of the tree at breast height.

Determining the Number of Logs in a Tree

Knowing the number of logs that a tree will produce is important in the timber industry. A log equals 16 feet. Logs are generally measured using a Biltmore stick. Starting from the base of the tree (where the stump would be if the tree were cut down) up to where the tree has an eight inch diameter or forks (splits). The Biltmore stick is one of the instruments specifically designed to give accurate readings only at 66 feet. It uses principles of geometry and similar triangles to produce these measurements. (See determining height on page 55 for details.)
Other Important Forestry Measurements

There are many other measurements you will come across in your study of forestry. Some of these are listed here:

- **Board Foot** - an imaginary piece of wood measuring 12 inches long by 12 inches wide and 1 inch thick. It equals 144 cubic inches of wood or lumber. Board feet (B.F.) are determined using diameter measurements and the number of logs a tree will produce. There are tables on most Biltmore sticks that convert these two measurements into board feet.

- **Cord of wood** - a cord of wood is the amount of lumber that exists in a stack of wood 4 foot high by 4 foot wide and 8 foot long. This equals 128 cubic feet of wood and air space. Air space must be included because the trunk of the tree is round and it is impossible to eliminate all of the air space from the stack.

- **other uses for the Biltmore Stick include:**
  - Diameter of a log
  - Diameter of a standing tree
  - Volume of timber in a log
  - Volume of timber in a standing tree
  - Height of a tree
  - Number of logs in a tree

How to use a Biltmore Stick to Determine Height and Diameter

**Diameter**

1. Find four and half feet up from the ground. This is known as diameter at breast height and is where you will make your measurement.

2. Hold the Biltmore stick in a horizontal position 25 inches (the length of the stick) away from you with the left end of the stick along one side of the tree.

3. Close one eye and without moving your head, read where the other side of the tree lines up with the Biltmore stick. This is the diameter of the tree.
Height
The Biltmore stick is specifically designed to determine the amount of merchantable (saleable) timber. However, it can also be used to roughly determine the height of trees.

1. Pace off 66 feet, or one chain, in a straight line away from the upper side of the tree.
2. Hold the stick vertically 25 inches away from you with the end of the stick level with the base of the tree.
3. Using the scale on the stick count the number of 16 foot logs that could be made from the tree. Use your best judgment in determining what part of a log any area left would be.
4. To determine height in feet multiply the number of logs by 16 and then add any partial log (in feet) that may exist.

Site Index
Site index is a measurement of the overall quality of a particular stand (or site) of trees. It is based on the height of the dominant trees at a specific age. In the eastern United States this age is set at 50 years old. In the western United States site index is measured when the trees are 100 years old. Each tree species has its own site index. Charts have been made that determine what the site index is, and you simply read the chart. For example, a site index of 70 would mean that after 50 years the trees in the area would reach an average height of 70 feet.

Cruising Timber
The only way for a landowner or timber company to know what trees are marketable is by a timber cruise. Cruising is the estimation of the volume of standing timber. This may be done as a partial cruise where only a sample or fraction of the trees are measured or as a 100 per cent cruise where all the trees are measured.

A Wedge Prism
A prism is a thin wedge of glass that bends light rays as they pass through. Prisms are a simple, fast, very accurate tool for foresters. The wedge prism is used to determine which trees should be counted in a timber sample. It eliminates the
need for sample plots and individual tree measurements used in traditional cruising. The prism allows for point-sampling to select trees to count based on their size rather than on frequency as in traditional cruising.

The prism provides one of the easiest methods for estimating basal area, or cross-sectional area of trees at breast height. The basal area is used to determine:
- the degree of stocking of a stand of trees
- the amount of timber to remove in thinning an over-stocked stand
- timber volume

Prisms are ground to a specific basal area. The most common size is 10. The wedge prism is used to determine basal area as follows:

1. Hold the prism at eye level over the center of a point to be used to sample.
2. Look through the prism and count the number of trees, which should be tallied or recorded. (See figure below for determining what trees should be tallied.)
3. Multiply the tree count by the basal area factor of the prism to obtain the basal area per acre in square feet. (5 trees X BAF 10 = 50 sq. ft. basal area/acre)
4. Repeat the process at a series of points.
5. Average the basal area from all sampling points to calculate the average basal area for the stand.

Forest Ecosystems In North Carolina

Mountain Cove Forests
Mountain cove forests are found in the remote areas of the North Carolina mountains. They are home to some of the oldest, largest trees in the state. Their rugged and remote location has saved them from logging and other human development. Common trees in the mountain cove forests are tulip poplar, yellow buckeye, hemlock, and sugar maple. Other plant life found in this ecosystem includes trilliums, may apples, yellow-flowered violets, and foam flowers. Many ferns grow in this area, including the walking fern and the Christmas fern. The mountain cove forest is also home to a wide variety of wildlife, such as the black bear, bobcat, and a large number of salamander species - including the red-spotted (or Eastern) newt. These forest provides a temporary home for a wide variety of migratory songbirds.
Spruce Fir Forests (or Boreal Forests)
Spruce fir forests are common in the northwestern part of the United States and New England. In North Carolina, they only exist at the highest elevations, above 5,500 feet. This is a coniferous forest composed mostly of Fraser fir and red spruce. At first glance, these trees may look similar, but their leaves are actually very different. The leaves of the Fraser fir are flat, narrow, and straight. The leaves of the red spruce are more needle-like, pointy, and slightly curved. The climate and vegetation of these forests are different from elsewhere in the state, and many of its species are unique or unusual. It is the southernmost limit of the range for the tiny saw-whet owl, and it provides habitat for a subspecies of Northern flying squirrel. Today, the spruce fir forest is slowly being destroyed by air pollution and acid rain. It is important that we protect this unique forest, because it provides habitat for many endangered and threatened species, as well as, species of special concern. These include the Northern flying squirrel, Weller’s salamander, long-tailed shrew, Rugel’s ragwort, spreading avens, and Heller’s blazing star.

Piedmont Stream Forests
Piedmont stream forests are common in North Carolina. They often vary a great deal in size. They may be only a small strip of trees surrounding a stream, or they may be a much larger stand of trees with a stream running through it. No matter the size, they provide a home for a large number and variety of wildlife species. In fact, they are home to about half of the 200 species considered to be endangered, threatened, or of special concern in North Carolina. Some plants found within the piedmont stream forest are oaks, hickories, red and silver maples, river birch, persimmon, ferns, vines, weeds, bushes, and many types of wildflowers. Common animals in the piedmont stream forest include the southern leopard frog, salamanders, mink, turtles, deer, opossum, raccoon, southern short-tailed shrew, big brown bat, and southern flying squirrel. Fresh water mussels are often found in the streams of these forest. Many of the animals in the piedmont stream forest are nocturnal, which means they are most active at night.

The piedmont stream forest is important because it is often the only remaining habitat for wildlife in some cities. They provide a long “edge” habitat. These areas serve as cafeterias and highways for many wildlife species, making them important areas for food supply and movement from one area to another through highly developed regions. Many of the rarest mussels are found in piedmont streams, and these forests act as a buffer and help protect the area’s water quality.

Bottomland Hardwood Forests
These forests are composed of deciduous trees that grow in the floodplains of rivers and streams. The bottomland forest floods annually and is home to special trees adapted to survive these periods with their roots underwater. Two of these trees are the tupelo gum and baldcypress. On the higher drier areas, oaks, sycamore, beech, hickories, elm, and sweet gum trees grow.

The baldcypress looks similar to a coniferous tree because of its needle-like leaves, but it is actually a deciduous tree. It is related to the giant redwoods and sequoias found in the western part of the United States. The baldcypress grows knobs that are known as “cypress knees.” These knees grow straight up from the roots and...
Forestry — “In wilderness is the preservation of the world” Henry David Thoreau

help the tree taken in oxygen when the area is flooded. Cypress knees can grow as tall as five feet. Baldcypress trees in general can be quite large. They can grow to five or six feet in diameter, well over one hundred feet tall, and be 500 to 600 years old. The oldest baldcypress trees are found along the Black River and are estimated to be more than 1,600 years old.

Bottomland hardwood forests are home to a wide variety of plant and animal species. Common animals are wild turkey, barred owl, pileated woodpecker, water moccasin, bobcat, great blue heron, wood duck, and migratory birds and waterfowl. Common plant species are sedges, wild grapes, privet, and giant cane. Trees of the forest include cherrybark, willow, water, overcup and shumard oaks, black willow, sycamore, sweetgum, pawpaw, shagbark and water hickories, and red and silver maples.

The ivory-billed woodpecker once inhabited these forests and swamps. Logging, forest fragmentation, and indiscriminate hunting led to its extinction.

The bottomland hardwood forests are important, because they are wetland areas that act as filters for our soil and water. Floods regularly bring new materials, such as sediments and pollutants, onto the forest floor. The forest soil is enriched by the sediment, which it holds in place; and the forest acts as a filter to remove the pollutants. Bottomland hardwood forests absorb precipitation and prevent or decrease the amount of damage done when flooding occurs.

**Sandhills’ Longleaf Pine Forest**

The longleaf pine forest found in the coastal plain is a unique ecosystem. It is a fire dependent ecosystem. Fire is necessary for the native plants and animals to survive and not be taken over by other species. Many of the organisms found here have developed adaptations that allow them to survive fire and grow in spite of it. The dominant tree is the longleaf pine. Its’ dependence on and adaptations to fire have been discussed previously. Other plants found in the longleaf pine forest are turkey oak, Michaux’s sumac, wiregrass, and sandworts. Some animals of the longleaf pine forest are the red-cockaded woodpecker, fox squirrel, gray fox, pigmy rattlesnake, Eastern diamondback rattlesnake, Carolina anole, tree frogs, and Eastern king snake. The longleaf pine forest once covered much of the coastal part of the Southeastern United States from North Carolina through Florida. Much of this habitat has been lost, and the longleaf forest is quickly disappearing. The forests were cut for naval stores, harvested for timber, and cleared for development and other human activities.

**Trees Students Should Be Able To Identify**

<table>
<thead>
<tr>
<th>Hickory</th>
<th>White Oak</th>
<th>Eastern White Pine</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pecan</td>
<td>Red Oak</td>
<td>Longleaf Pine</td>
</tr>
<tr>
<td>American Holly</td>
<td>Persimmon</td>
<td>Shortleaf Pine</td>
</tr>
<tr>
<td>Sassafras</td>
<td>Maple</td>
<td>Ash</td>
</tr>
<tr>
<td>Dogwood</td>
<td>Sweetgum</td>
<td>Beech</td>
</tr>
<tr>
<td>Sycamore</td>
<td>Black Cherry</td>
<td>Yellow Poplar</td>
</tr>
<tr>
<td>Sourwood</td>
<td>Loblolly Pine</td>
<td></td>
</tr>
</tbody>
</table>
Forestry Resources

North Carolina Forest Service
www.dfr.state.nc.us
Local Forester
Publications available on various forest pests

U.S. Forest Service
www.fs.fed.us
Publications:
Managing the Family Forest in the South
The Values of North Carolina Trees
Insects and Diseases of Trees in the South

U. S. Department of Agriculture
Publications:
A Forester’s Guide to Observing Wildlife Use of Forest Habitat in the South
Important Forest Trees of The Eastern United States

North Carolina Cooperative Extension Service
www.ces.ncsu.edu
Pamphlets:
A Forest Landowner’s Guide
Woodland Owner Notes:
- Forest Stewardship: Planning for Beauty and Diversity
- Wildlife And Prescribed Burning – Fire As A Forest Habitat Management Tool
- Wildlife and Forest Stewardship
- Forest Soils And Site Index

American Forest and Paper Association
www.afandpa.org
“Sustainable Forestry”

The National Arbor Day Foundation
What Tree Is That

Soil and Water Conservation District Offices
“Buffers”

Eastern Forests, National Audubon Society

Common Forest Trees of North Carolina, NC Division of Forest Resources
Forestry – “In wilderness is the preservation of the world” Henry David Thoreau