



# Forestry Resource Manual

*Adapted from North Carolina Envirothon Forestry Resource Manual  
Revised July 2018*

# Delaware Envirothon Forestry Learning Objectives

Students must be able to...

## A. Understand the historical roles of forests in society

1. Know the historical role and importance of forests
2. Explain the various benefits of trees and ecological roles of forests
3. Explain the importance of trees in urban areas and aspects of urban forestry
4. Understand forest land use and ownership in Delaware
5. Know the economic value of forests and the many products they provide

## B. Understand and describe the physiology of trees and methods for their identification

1. Know the different parts of a tree and their functions
2. Explain the reproduction of the two main types of trees.
3. Describe the lifecycle of a tree and explain how trees grow
4. Understand the method and terminology required to use a dichotomous tree key
5. Know and identify major tree and shrub species native to Delaware's forests

## C. Understand and describe the various characteristics and processes of forest ecology

1. Understand the concept and processes of forest ecology.
2. Identify the abiotic and biotic components of a forest ecosystem
3. Explain the process of photosynthesis and nutrient cycling
4. Understand and illustrate the process and stages of succession
5. Understand the developmental stages, structuring, and types of forests

## D. Understand and describe the methods and practices of sustainable forest management

1. Identify and describe the various silvicultural principles and treatments
2. Understand tree harvesting and regeneration methods
3. Describe the various forest management objectives
4. Explain forestry best management practices
5. Explain the forest management cycle and each of its component parts

## E. Understand and describe the methods and tools used in a forest inventory

1. Understand the importance of forestry measurements and identify the tools used for each
2. Demonstrate proficiency using various forestry tools and interpreting the collected data
3. Explain plot measurement procedures used in a forest inventory
4. Understand and explain the various objectives for completing a forest inventory
5. Explain what site index means and know to read a site index graph

## F. Understand and describe practices involved in the conservation of forest resources

1. Explain the importance of forest health
2. Understand the major issues affecting Delaware's forests
3. Identify Delaware's main forest pests and diseases
4. Understand the programs available aimed at conserving forest resources
5. Explain the various laws and regulations aimed at conserving forest resources

# Key Concept 6: Conservation of Forest Resources

## *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 that is 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. Humans are responsible for the majority 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 humans. Many of the organisms that threaten forests today are **alien, or exotic, species**. Alien species are organisms that are brought by people into an area where they are not native. 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, balsam woolly adelgid, hemlock woolly adelgid, Asian longhorn beetle, sudden oak death, emerald ash borer, chestnut blight, and Dutch elm disease are examples of destructive exotic species introduced to American forests. While careless actions by humans 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.

### *Southern Pine Beetle*

The southern pine beetle is about the size of a single grain of rice, but it is the most damaging insect, causing millions 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 in 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 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 the beetle 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 of the bark boring beetles described here. 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, causes less damage than the Ips and southern pine beetles. 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, logging the infected trees, or using natural predator insects. The preferred method of control is logging and removing the infected trees.

### *Emerald Ash Borer*

A new comer from Asia and found in Michigan in 2002. As of 2014 it has expanded its range to include over 24 states and Canada. It was found in North Carolina in 2013 in several northern counties bordering Virginia, and even more recently in Wake County. Adults lay their eggs in the crevices of the bark of ash trees. When the larvae hatch they bore through bark and feed on the cambium. The larvae kill the ash tree by girdling the tree. Adults emerge through a “D” shaped hole in the bark that is approximately one eighth of an inch in diameter. Adults feed lightly on leaves usually causing little damage.

### **Leaf Eaters and Tip Feeders**

These insects eat all or part of the foliage or cause malformations or discoloration by sucking the sap or feeding 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, sweet gum, 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. This prevents the tree from making adequate food through photosynthesis because the larvae defoliate the trees. 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 Woolly Adelgid*

This sap sucking, tip-feeding insect is primarily a concern for North Carolina's Christmas tree growers. They are invasive from Europe. Mortality rates have been 90-99%.

#### *Hemlock Woolly Adelgid*

Invasive insect from Asia. Feeds only on hemlocks and kills them. Hemlocks are ecologically important as a riparian species where they keep the mountain streams cold and allow the trout to survive. Hemlocks are a shade tolerant species that have survived for thousands of years and have developed a large ecosystem which benefits many bird and animal species.

#### *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 feed 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 longleaf pines. Longleaf 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 harvest when trees are mature.

### *Fusiform Rust*

Another group of forest diseases that cause many problems for trees each year are the rusts, which are 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. Trees with fungal galls should be removed as soon as possible to stop the fungus from spreading. Trees with insect galls do not necessarily have to be removed, because they generally pose no immediate threat to the other trees.

Loblolly and slash pine are two of the species that are most susceptible to Fusiform Rust. Infected trees develop galls on the main stem or twigs. These galls are weaker than healthy tissue and make the tree vulnerable to breaking. In the spring when the fungus starts to produce spores, the gall will turn a bright orange.

Fusiform Rust is one of the most economically important diseases in the southern forest.

### *Heart Rot*

This fungus is the single most damaging disease to merchantable hardwood timber. Heart Rot causes decay at the center of the stem and branches causing the tree to weaken. The fungus enters the tree through damage to the bark.

### *Oak Wilt*

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

### *Sudden Oak Death*

A disease which was first recognized in California in the 1990's. The disease has resulted in the widespread dieback of several tree species. It is invasive and leads to the rapid death of susceptible species.

### *Dutch Elm Disease*

A fungal disease that kills elm trees. It is carried by bark beetles and slowly kills the trees by stopping up the vascular tubes.

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. Around 1900, a fungal disease, known as chestnut blight, was accidentally introduced to the US from Asia. Within thirty years, chestnut blight had killed almost all of the chestnut trees in the United States.

## **Fire**

In unmanaged forests or where fire has been suppressed for long periods, wildfires can be devastating. Fires, 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 longleaf 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 longleaf 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 an 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 taproot 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 the pole stage of its life. 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 longleaf 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