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 biotics 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 3: 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 of plants and animals in 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. This is the forest ecosystem.

The organisms within the forest ecosystem may be **producers, consumers,** or **decomposers**. *Producers* are green plants and can make their own food using the sun as the energy source. They are essential to 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 other consumers. When the producer or consumer dies, the *decomposers* break down the plant and animal matter to be nutrients essential for plant and animal growth, such as nitrogen, phosphorus, and sulfur. Bacteria and fungi are the main decomposers.

Many organisms have developed relationships in which they live together or in close association with other organisms. 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. **Parasites** benefit from a relationship, while the host is usually harmed and may even die as a result of the parasitism. Lichens found on some logs are a mutualistic relationship between an algae and a fungus. A **mutualistic** relationship is one where both parties benefit from the relationship and neither is harmed. 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 **commensalistic** relationship is where one organism benefits from the relationship and the other organism is neither hurt nor benefits.

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 of the same species and different species. This is a mutualistic relationship because the mycorrhizae receive sugars from the tree in addition to the benefits the tree receives.

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. **Resource partitioning** is the process where similar species use limited resources in an area without one species driving others into extinction. 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. A tree's 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.

A 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 found, and some eventually grow into new trees. Many are carried to new locations, which prevent competition with the parent tree and the newly emerged seedling. In these cases the tree usually produces an excess of nuts, enough nuts for the animals to eat and to have enough left over for new seedlings.

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 red heart disease. It uses a living tree to make its nesting cavities. 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 a large variety of plant and animal species. A pasture, a cornfield, or a loblolly pine plantation is an

example 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, because there is little diversity of tree species found there. In this case another habitat type would develop without human intervention.

Within an ecosystem, there may be many **micro-ecosystems**. These are small areas that are part of a larger system, with their own set of complex interactions occurring within them. A dead snag, a beaver pond, and a decaying log are examples of micro-ecosystems 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.

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 limbs and foliage on the lighted side. Some develop larger leaves to catch the scattered light in an understory condition. 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 that makes harmful chemical elements like aluminum available for trees to take up.

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. If tree roots are covered for an extended period of time by water and cannot get oxygen, they will die, thus killing the tree. Some trees are more tolerant of wet conditions while others can live in rather dry areas. Trees that can survive having their roots in wet conditions include red maples, beech, cypress, willow and birch. How wet an area is determines which species will grow there.

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 all other organisms on the earth. Photosynthetic organisms are the producers.

Photosynthesis

Carbon Dioxide + Water + Sunlight = Sugar (Glucose) + Oxygen + Water

Respiration

Sugar (Glucose) + Oxygen = Carbon Dioxide + Water + Energy

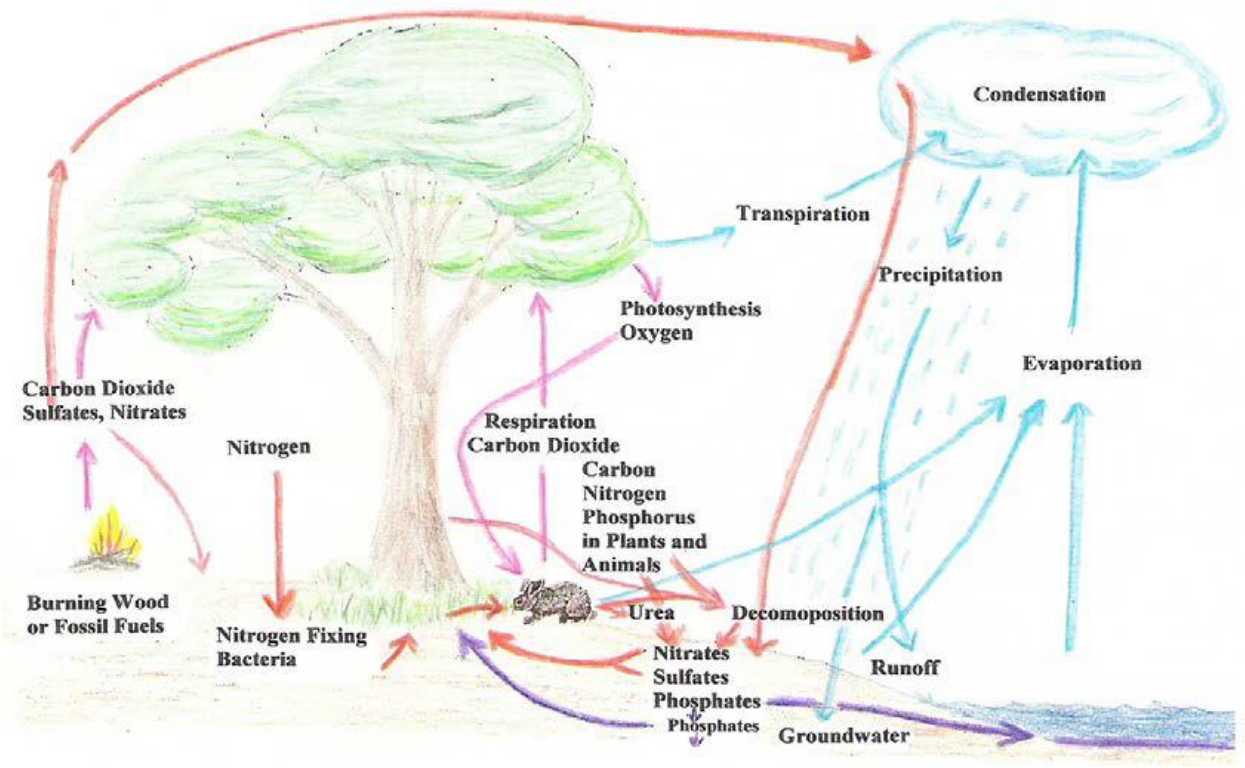
$6CO_2 + 12H_2O \rightarrow C_6H_{12}O_6 + 6O_2 + 6H_2O$ ***The chemical equation for photosynthesis***

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.

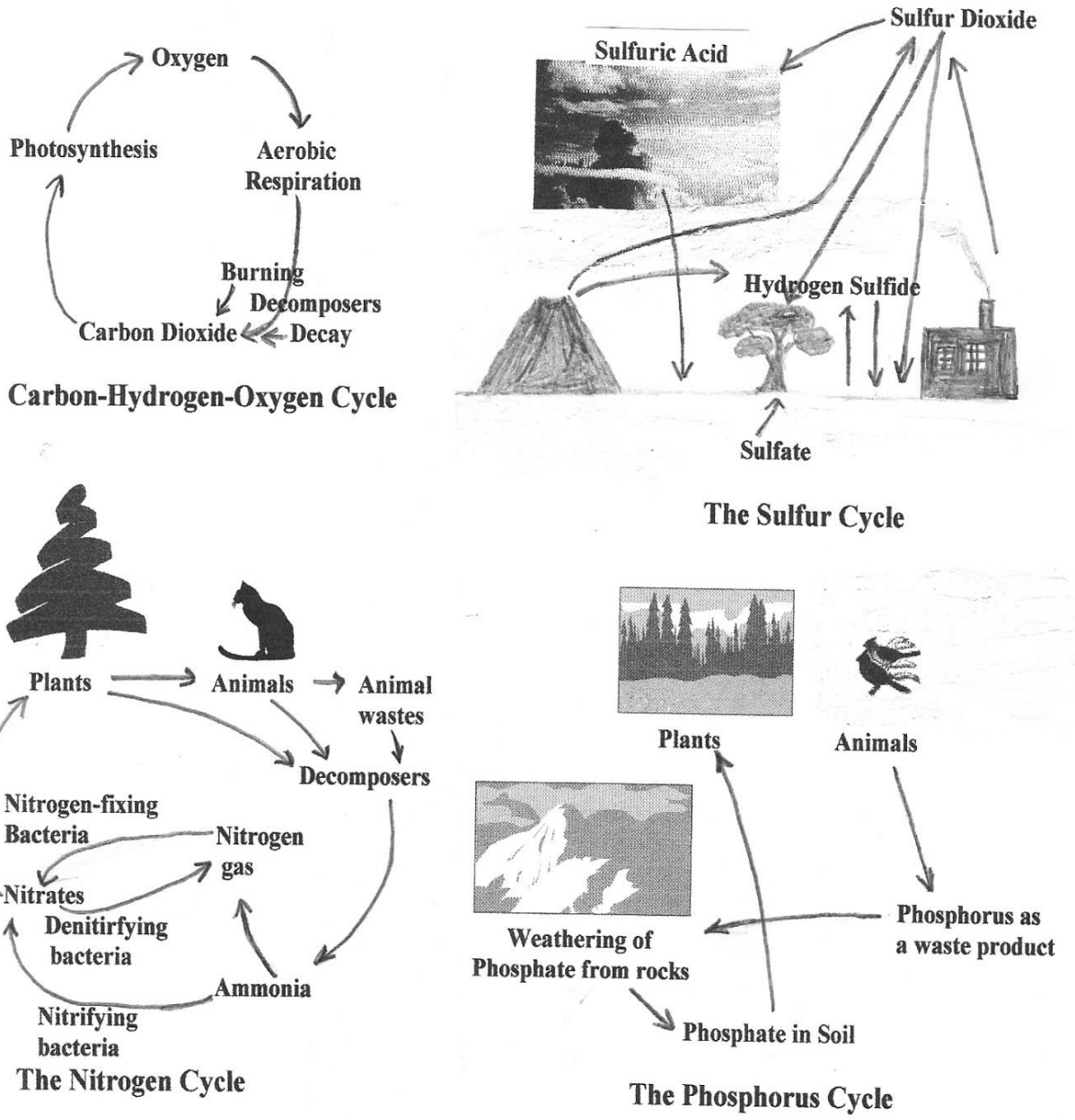
These two processes, photosynthesis and respiration, are the opposite of one another. Both processes are essential for all life, and ultimately all life is dependent on the sun's energy, which makes photosynthesis possible.

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 life processes to recycle these nutrients. The nutrients are then returned to the ecosystem from waste matter excreted or from the organisms' bodies when they die. Bacteria and fungi break down dead organic matter and return the nutrients to the ecosystem. These organisms are the **decomposers**.



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



The individual biochemical cycles

Forest Soils

The soil is another abiotic factor in the forest ecosystem. The soil anchors the tree and serves as its growth medium. It also contains 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 acidic due to the components of a pine tree being slightly acidic. 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.

- **Topsoil depth**- the topsoil 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 and water from going downward any further. 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 because of the larger pore spaces.

Forest soil provides many ecological benefits to the ecosystem. The soil contains many microorganisms that are important for plant growth. Mycorrhizae fungi, which attach to plant roots, convert atmospheric nitrogen to a usable form, aid in water and nutrient uptake, and helps in the transfer of nutrients and water to other trees which may not get enough due to their location. 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 many of the decomposers, which keep the forest floor clean by feeding on the dead and decaying material found there and recycling 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 tree 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 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.

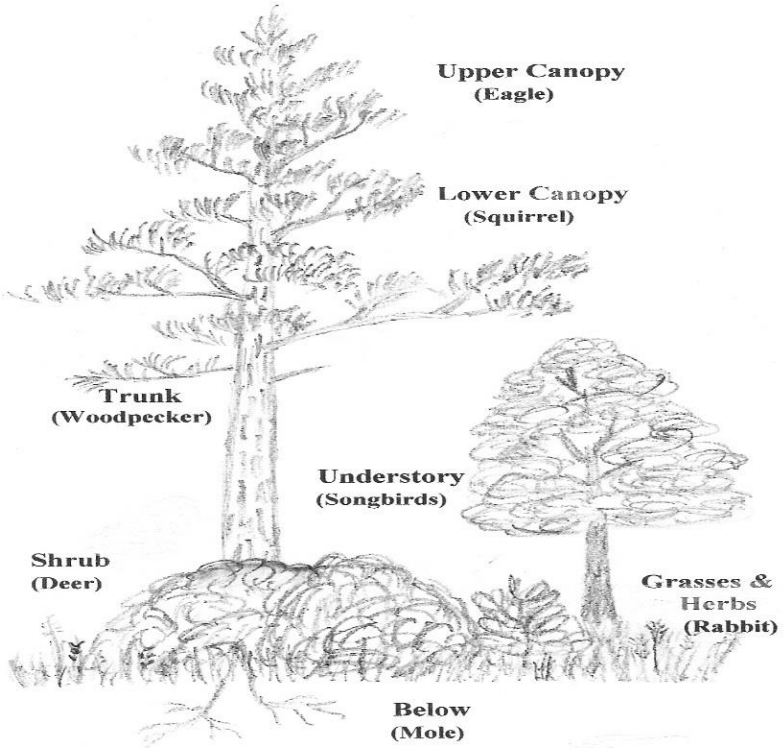
- Seedling stage – from seed to 5-15 years, the beginning of the closing of a stand.
- Sapling stage – from the closing of the stand to death of lower limbs and crowns well above the ground.
- Pole stage – from sapling stage to limb clearing of most of the trunk and decline in height growth.
- Young 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.

At the mature timber stage, the tree actually starts to use more oxygen than it will produce.

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, different species 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 on or in the ground or soil layer. Foxes, deer, and salamanders live on the forest floor. Various insect and bird species live in, use or occupy different layers of the trees along with animals, such as raccoons and squirrels.

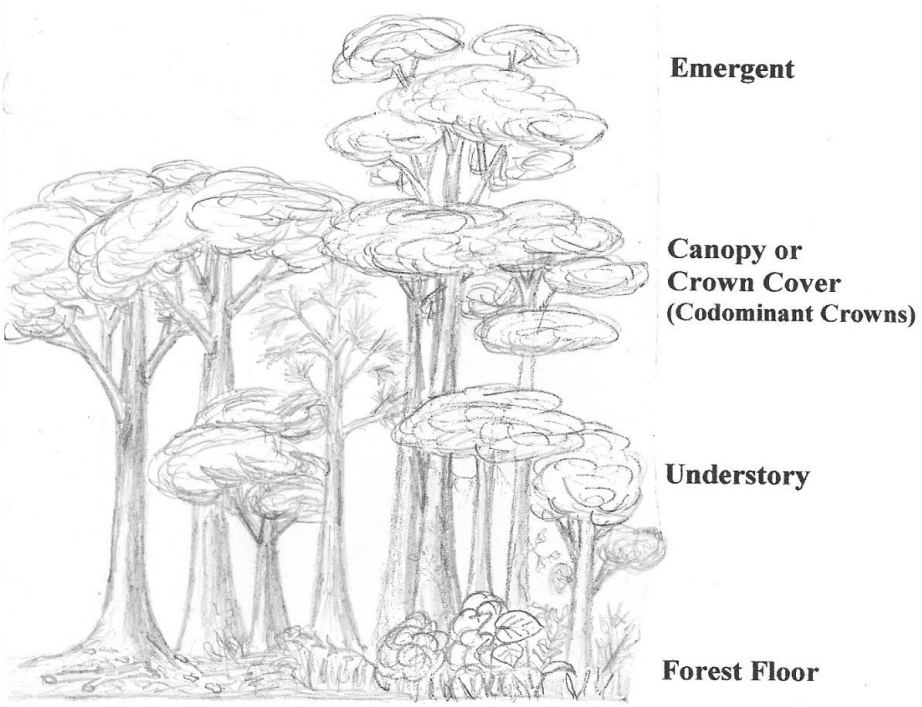


Vertical Stratification and associated Wildlife

The lowest 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 recycling 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 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 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 dominant 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. The tree produces both male and female cones with the male cones usually lower on the tree and the female cones higher to keep pollen from fertilizing its own seed. It takes about 2 years for a pine tree to go from pollen to a fully developed seed inside of a female cone. 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 making up its composition. Most of the forest in Delaware is mixed.

Coniferous forests contain trees known as conifers. Conifers are evergreen trees with needle-like or scale-like leaves, and bear their seed in cones. *Evergreen* trees keep their leaves all year. Leaves drop off as they are damaged or die from old 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**.**

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, being 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 genera are pine, hemlock, fir, spruce, and cedar. Specific coniferous species found in Delaware include the eastern white pine, shortleaf pine, loblolly pine, longleaf pine, pitch pine, Virginia pine, pond pine, eastern hemlock, Atlantic white cedar, and eastern red cedar.

Coniferous forests usually grow in dense communities with little diversity. Sometimes, a stand of coniferous trees will only include two or three different trees 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 decompose 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 last 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.

Delaware has a diverse population of deciduous, or hardwood. These genera include oak, hickory, maple, ash, poplar, beech, birch, black gum, and many more - each including multiple species. Deciduous trees are much more diverse than conifers.

Deciduous trees can be identified by the shape and size of their leaves, their bark, buds, and the fruit. Deciduous forests 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, these include both bald and pond cypress, as well as the 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 bald cypress 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 harvested for years before their true value was recognized. In Europe two-thirds of the old growth forests have been cut and the United States has cut 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 have many 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 this kind 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 wider variety of plant and animal species.

Forest Stages

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, red maples, and black tupelo. Others can tolerate the temperatures and conditions of North America's highest slopes, known as **boreal forests**. 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, wildflowers, native grasses, and some shrubs and forbs. 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.

Young Pine Forest

Middle-aged Forests

The middle-aged forest is made up of trees of relatively small diameter. Some of the grasses, forbs, 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 understory cover and food for small wildlife becomes scarcer. The mid-story tree level produces an increased amount of **mast**, seeds and fruits, including wild cherry, wild grape, mulberry, hickory nuts, holly berries, persimmon, beech nuts, sassafras, black walnuts, acorns, black gum, pecans and flowering dogwood.

Middle Age Forest

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 mid-story or forest floor. This light encourages the growth of woodland wildflowers, ferns, herbs, and shrubs containing berries 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.

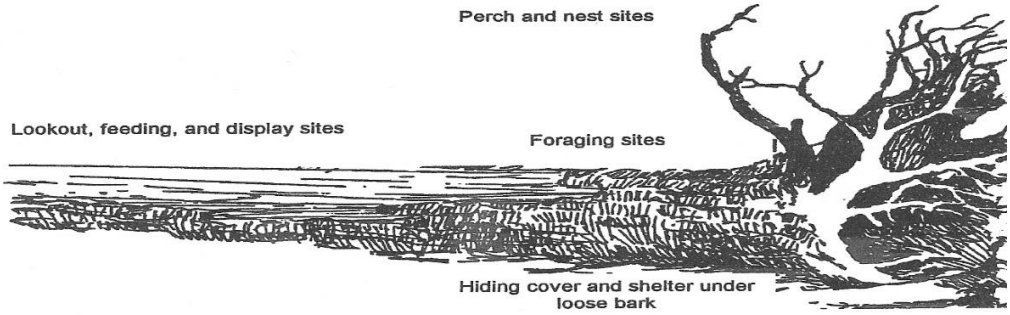
An important component of a mature forest for wildlife are the **snags**, which are standing dead or partially dead trees. Hard snags are trees that have died recently and still retain some limbs, are mostly sound in their interior, and have fairly intact outer bark. Soft snags typically have no limbs, 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.

Overly Mature Forest

Downed logs of the mature forest are an important micro-ecosystem. 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 uses these logs. Woodland salamanders may lay their eggs under the moist decaying log, snakes may hide under or in them, rabbits may use holes in them to hide, insects, spiders, shrews, and squirrels may sit up on them eating a nut, or birds may use them to look for insects to eat. Downed logs are important for another reason. As the bacteria and fungi, the main decomposers, break them down, essential nutrients are returned to the forest ecosystem to aid the growth of new vegetation. Some new trees, ferns, or forbs may actually be found growing on the downed logs.

These forests offer a wide variety of recreational opportunities including hunting, birding, camping, wildlife observation, wildflower enjoyment, and nature study. The mature forest trees can also produce good saw timber for homebuilding and furniture.



Downed logs provide for many wildlife needs

Snag Users

Birds

Red-bellied Woodpecker
Pileated Woodpecker
Great Crested Flycatcher
Prothonotary Warbler
Carolina Chickadee
Eastern Bluebird
Common Flicker
Tufted Titmouse
Wrens
Wood Duck
Nuthatches
Barred Owl
Screech Owl
Turkey Vulture
Red-tailed Hawk

Downed Log Users

Birds

Ruffed Grouse

Mammals

Shrews
Chipmunk
Cotton Mouse
Red-backed Vole
Black Bear
Mink
Bobcat
Star-nosed Mole
Deer Mouse
White-footed Mouse
Gray Fox
Long-tailed Weasel
River Otter

Amphibians/Reptiles

Salamanders
River Cooter
Yellowbelly Slider
Carolina Anole
Eastern Fence Lizard
Bullfrog
Painted Turtle
Box Turtle
Snakes
Skinks

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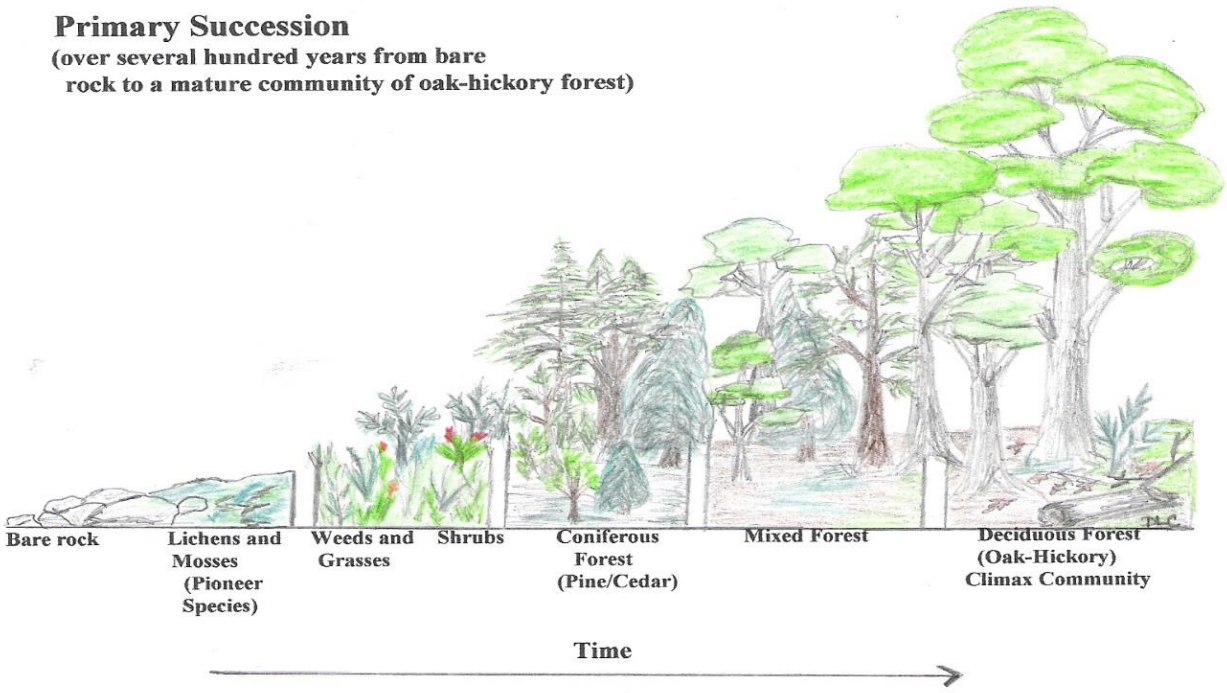
Change is the one constant in all communities and ecosystems. **Succession** is the regular pattern of change over time that takes place in an ecosystem. Because we do not know the normal range of most variables in an ecosystem or the effects of small, random events on changes in ecosystem structure 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 symbiotic relationship where both organisms help one another. They eat 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. Forbs, 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 as they shed dead leaves and twigs and when they die. 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 forb 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 several 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 than 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 replace 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, insects and disease.

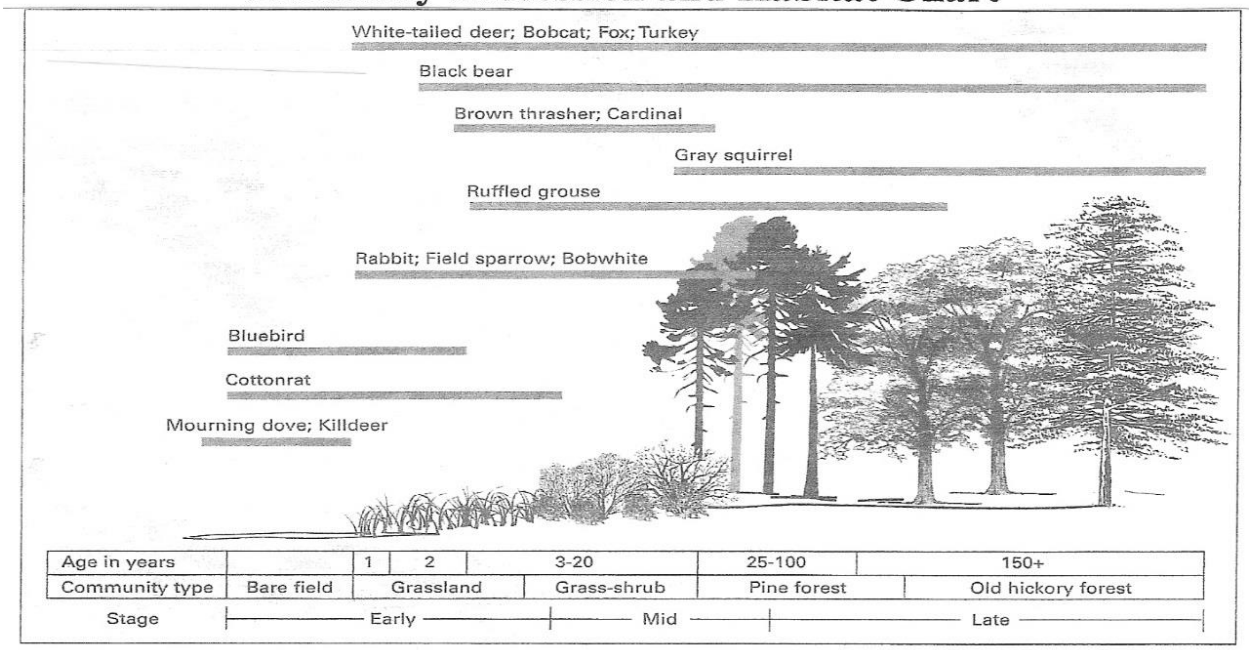
Sometimes an area experiences a major disturbance and the plant and animal life changes. Such an area would then undergo another type of succession known as secondary succession.

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 forbs 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 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. The tendency toward greater variety and density of plant and animal populations in an ecotone is known as the **edge effect**. Some examples of ecotones are where dry land meets a lake or where open fields border a forest.

Secondary Succession and Habitat Chart



Age in years		1	2	3-20	25-100	150+
Community type	Bare field	Grassland		Grass-shrub	Pine forest	Old hickory forest
Stage	Early			Mid	Late	

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