Forests of Great Smoky Mountains National Park

By Amber Parker

Most national parks are known for particular defining characteristics. Yellowstone has its hot springs and geysers, Yosemite is known for its stunning rock faces and waterfalls, and Acadia has its rocky seashore and stony mountains. Great Smoky Mountains National Park's hallmark is its biodiversity, particularly plant diversity, and the expression of that diversity in the magnificent forests that blanket most of the park. This diversity is the result of a perfect nexus of place, time, geology, topography, and climate.

In the half-million acres of Great Smoky Mountains National Park there are more tree species than in all of Europe and over 1,400 species of flowering plants. These trees and other plants, as well as mammals, reptiles, amphibians, birds, insects, and other invertebrates are the components of our forest ecosystems. Their interrelationships give a forest its character and create in it a living system. There are six major forest types in the national park: mixed hardwood, pine-oak, Eastern hemlock, cove hardwood, Northern hardwood (including the subtype gray beech forest), and spruce-fir forest. Each of these forests are unique in their composition, structure, and location in the national park. Each is a small microcosm waiting for your exploration.

There are countless hours of nature study to be had in Great Smoky Mountains National Park. Many of us spend much time looking for wildflowers, birds, trees, or salamanders. Learning to identify these species is a joy, particularly if identification leads to knowledge about their life histories and relationships with other species. The purpose of this document is to help you begin to look for those relationships as they are manifested in forest ecosystems. Forests are complex networks of these relationships and the more you discover about them, the more complex and magnificent this national park becomes. To recognize and understand the components of forest systems and the relationships between those components is to truly understand the diversity and wonder of Great Smoky Mountains National Park.

What is a forest?

A forest may be defined as an area of land, of more than 0.5 hectares (1.24 acres), with a tree canopy cover of more than 10%. A forest type is a group of forests that, via characteristics such as tree and under-canopy composition, can be differentiated from other such groups. A forest is recognized by the tree species that compose its canopy and, often, by other species that make-up its sub-canopy, shrub layer, and herbaceous layer.

A forest is organized in layers. The canopy is the upper-most layer that is composed of the crowns of the tallest trees. These trees receive most of the sunlight that falls upon the forest. The next layer down is the sub-canopy, which is often composed of smaller trees, some that never gain the full height of the canopy trees and other that are simply young versions of trees in the canopy. These trees include many of our favorite flowering trees such as eastern dogwood, redbud, and sourwood. They form a layer many feet below the canopy trees. Next we come to the shrub layer. This layer is usually little more than head height and is composed of shrubs such as rosebay rhododendron, mountain laurel, blueberries, and Viburnum. Below the shrub layer is the herbaceous layer. It is composed of mostly deciduous plants that, in some forests, such as the cove hardwood, will form additional layers on the forest floor.

Each forest layer and its parts are ecological niches in which other species make their livings. Some birds, such as the red-eyed vireo and northern parula warbler faithfully remain in the canopy of the forest, feeding on insects and nesting in the lofty branches. Other birds like the hooded warbler prefer to nest in the shrub layer, never venturing into the heights of the forest, and still others are ground nesters. We see this same preference for layers in other animals. The golden mouse's arboreal habits find it going about its business in the canopy and sub-canopy while the deer mouse remains on the ground. Even fireflies segregate by layer, some displaying a few feet from the ground and other's preferring the high canopy.

As you learn about a forest, you should note, not only the species that compose the canopy but also the make-up of each forest layer and to what degree that layer is developed. Are there many trees in the sub-canopy? Is the shrub layer thick and impenetrable or almost nonexistent? Are there many plants on the forest floor or very few? Identification of these plants is important to understand the forest in which you stand. Many indicate the relative moisture levels in the forest. For example; lots of silverbell and yellow buckeye means mesic or moist soil conditions, many pines indicate more xeric or dry soils. Some plants such as shooting star may indicate basic, limestone soils while Galax grows in acidic soils. Use these and other clues to form an hypothesis about the forest surroundings and identify the forest in which you stand.

Old Growth Forest

Approximately 25% of forests in Great Smoky Mountains National Park are considered old growth, making this one of the largest areas of temperate, deciduous old growth forest remaining in North America. These forests are usually found in areas of the park that were harder to log and some in places that loggers never reached. There are examples of old growth in almost all forest types, however some, due to growing conditions, may not reach the prodigious size we expect in "old growth". Excellent examples of old growth cove hardwood forests can be found throughout the park although many believe that Albright Grove is the most outstanding. There spectacular big, BIG trees, some more than 6 feet in diameter, seem to live in a world out of time. Compare that to some of the park's more xeric old growth forests where drier, less hospitable conditions created 450 year old oaks and hickories that barely reach two feet in diameter and you will see that we can't judge a book by the cover or an old growth forest by the size of its trees.

Old growth is often used to describe a forest that has experienced little or no direct impact by European-Americans and that looks like it would have if Europeans had not come to America. This definition can be difficult to apply because it is often impossible to know the history of human disturbance, whether by European-Americans or Native Americans. Also, because landscapes are dynamic and ever changing, we have no real certainty what our pre-Columbian forests would have looked like.

In order to have a standard definition for old growth, many botanists require that a forest have certain characteristics. Under this system, forests of enough age and minimal disturbance are considered old growth. Characteristics of old growth include:

Mixed age – A forest of mixed age is considered a long-term, stable ecosystem.

Light gaps – Openings in the canopy or light gaps, created by natural disturbances, are important in maintaining mixed-age stands. They provide opportunity for young trees to gain enough light to grow and eventually fill the canopy and create microclimates that in turn create diversity in the understory.

Pit and mound topography – Pit and mound topography is the characteristic rise and fall of the land after trees have fallen that causes pits where the roots have pulled out and mounds where the root ball decays. These places mix soil and humus layers and create microhabitats for plants that prefer those areas.

Standing snags – Standing snags, or standing dead trees, provide habitat and food sources for many types of animals, plants, and fungi.

Downed and decaying wood – Logs and other woody debris return their carbon-rich organic material directly to the soil, thereby completing the life/death cycle. They provide substrate form many mosses and fungi and for seedling. In more mesic sites logs will often become "nurse logs" providing seedling substrate for seedlings of many types of plants.

Intact soil – Intact soils have well-defined horizons or soil profiles. They are habitat for many life forms and should have a well-developed fungal community that assist with recycling of nutrients back into the entire ecosystem.

Why should we want to know the forest types?

The ability to recognize forest types is important if you wish to better understand where species, plant or animal, can be found. Forests and other plant communities form the foundation habitat in which most organisms make their living. Forests provide food, shelter, and space for all the insects, birds, reptiles, amphibians, mammals, and yes, even the plants that inhabit them. However, all plants and animals do not live in all forest types. Knowing how to identify forest types and their plant associations is helpful if you want to find and observe a particular plant or animal. For example, most field guides give habitat information for each organism they describe. They might say that the chestnut-sided warbler is found in spruce-fir forests or that blue jays are common in mixed hardwood stands. Knowing the basic requirements for these forests (moisture levels, elevation, aspect) will help you to determine where, on a map, you might find them and recognize them when you get there. In turn, when visiting a new area of the park you can easily gaze around you and deduce the type of forest in which you stand. At that point you will be able to make guesses as to which species you should expect to see and, as important, which ones you shouldn't. This makes you a better observer and prepares you for a good exploration of the area. Recognizing forests, and the species that compose them, is the best way to appreciate the biological riches within the national park.

Why does Great Smoky Mountains National Park have such a diversity of forest types and plant communities?

The great diversity in Great Smoky Mountains National Park, is due to a perfect combination of geologic time, location, geology, topography, and climate. The great age of the Appalachian mountain chain is one of the main factors for the national park's diversity. These mountains are some of the oldest on earth. The older the area the more time it has to develop new species. The Smokies are also fortunate it their geographic location. Glaciers did not cover them during the Pleistocene ice ages, when a sheet of ice covered all of the northern parts of the continent. This means that the Smokies plant and animal communities were not uprooted and forced to reestablish themselves after the ice age ended. Instead they were able to continue on and even accepted many of the plants and animals that migrated south during the glacial period. Species that had existed here for millennia continued to thrive and northern species found refuge as glaciers pushed them south. Today many of these northern species remain in high elevation retreats while species common to the south are found in the lower,

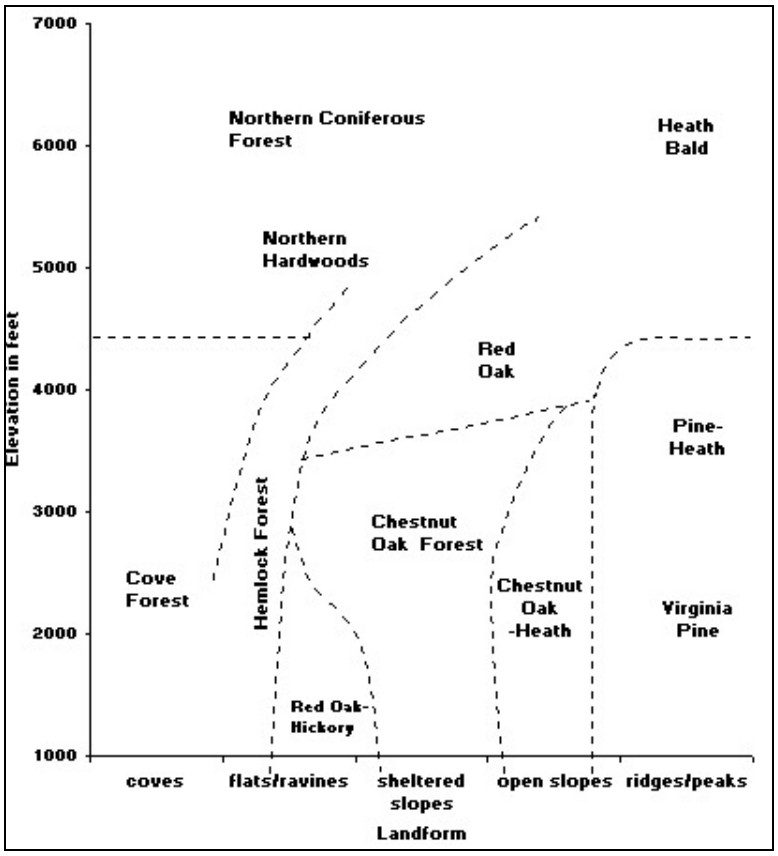
more temperate elevations. The geology of the Great Smokies, their rocks and soils, is complex and therefore the plants that inhabit these soils are diverse. The complex topography and elevations of the mountains create this diversity of climatic conditions. These varying climatic conditions provide a wide range of habitats for many species. Today, Great Smoky Mountains National Park offers growing conditions that resemble conditions found from Georgia to the cool climates of Maine. This diversity of climate gives the national park a variety of forests and plant communities that make it a paradise for natural history study.

Forest types are recognized by their specific associations of trees and plants. These associations occur as a result of the plant species preference for particular combinations of environmental factors such as moisture, elevation, topography, aspect, and soil composition. Great Smoky Mountains National Park, because of its size and complex landscape, offers many different combinations of these environmental factors and therefore contains a great diversity of forest types and plant communities.

The relationships between where a natural community is located and the gradients of the environmental factors that affect that community are strong and are primarily controlled by topography. The vegetative communities in the Great Smokies are affected by a combination of moisture and temperature gradients that depend on landform and elevation. Landform refers to the shape of the local and surrounding terrain. It also describes the aspect or direction in which the slope or ridge is facing. Elevation and landform affect temperature and moisture gradients. Low elevations receive less precipitation and have warmer climates than higher elevations. Concave landforms, such as ravines or valleys receive more moisture, in the form of runoff from the surrounding hills and slopes. In contrast, convex landforms such as peaks and ridges are drier, because rain that falls on them runs off. Side slopes maintain an intermediate moisture gradient because they gain moisture from upper slopes but also lose it to lower slopes. Whether a site is located on a south-facing ridge that is exposed to high levels of wind, sun, and temperature, whether it is located in a protected, north-facing ravine, or other location can greatly affect the plant species that can thrive there.

Vegetative Community Distribution

In the mid-1900's Robert Whittaker published his study of the vegetative communities in Great Smoky Mountains National Park; which was the first to describe how temperature and moisture gradients, coupled with elevation and landform affect the distribution of vegetative communities in the national park. A discussion of forests and plant communities in Great Smoky Mountains National Park would not be complete without including the elegant model created by Whittaker to graphically demonstrate the distribution of plant communities.



Note that Whittaker includes in the y-axis the elevation in ascending feet. Along with an increase in elevation we can also assume a similar increase in moisture and a decrease in temperature. The x-axis shows the landform as it moves from the most protected to the most exposed, or concave to convex. We can see then that plant communities show a definite preference for certain combinations of elevation, landform, and moisture. For example, cove hardwood forests are found in the most sheltered areas of the Smokies from the lowest elevations to approximately 4,500 feet elevation. In contrast heath balds are only found on the most exposed ridges and peaks. Hemlock forests, on the other hand, seem adapted to many conditions and are found from low elevation protected areas to high elevation open slopes. We can assume that hemlock forests are able to withstand more exposed conditions due to the fact that available moisture increases with increase in elevation and temperature decreases, mimicking the conditions of the sheltered areas in the low elevations.

Aspect is an important factor that affects plant distribution. Orientation to sun can affect where certain plant communities will thrive. Communities on exposed, south-facing slopes or ridges received a great deal more sunlight than those in protected, north-facing valleys. The more exposure to sunlight, the hotter and drying a community will be and the opposite is true for those that never receive direct

sunlight. An understanding of how aspect, elevation, moisture and temperature gradients affect plants and their forests, will assist you in recognizing and even predicting the type of forest in which you may take your next walk.

It's all about relationships: examples of complexity

Forests are, in their very essence, complex networks of relationships. At the most basic level is the relationship of soil and plants. Plants rely on particular nutrients and moisture levels in order to survive. Therefore, plants that prefer basic, limestone soils will not thrive in acidic soils. In turn many plants, such as Eastern hemlock, affect the acidity of the soils in which they live, making it too acidic for other plants to live there. On another level, many insects are particular about the plants upon which they live and feed and many birds prefer certain insects as their prey. Some of those same birds prefer to nest in particular habitats, science tells us that this is because of the available plant structure and nesting materials. But could it also be due to the insect prey that are attracted to the vegetation? These birds feed on the insects in their habitat, which in turn keeps the insects from completely denuding trees and shrubs in the area and thereby removing the leaves that provide the birds cover and protection.

Another example of an amazingly complex relationship is the one between calcium levels in soil, eastern dogwoods, acid rain, wild birds, and snail species. None of which seem, at least in the beginning, to relate to each other. Now we know otherwise. Land snails rely on finding a ready supply of calcium in which to create and maintain their shells. Most of the soils in the Great Smokies are acidic and lacking in significant amounts of calcium, but the flowering dogwood does a great job at bringing calcium to the surface through its roots and leaves, making the forest floor less acidic and more hospitable for calcium-loving species. However, dogwoods are declining in the park because of an introduced fungus pathogen called Dogwood Anthracnose. As dogwoods decline they are being replaced in the forest understory by Eastern hemlock, which acidifies the soil. At the same time acid deposition in high elevations is causing calcium to be leached out of the soils. Therefore there is a concern that lack of available calcium is causing a decline in land snail populations. The shells of land snails provide an important source of calcium for birds that need to increase calcium for egg-laying. Scientists have proven that reduced levels of calcium negatively impacts egg-laying success in wild birds. Therefore we can see that there is a relationship between soil calcium levels, snails, dogwood trees, and birds.

These are just a few of the many relationships that happen daily in a forest. There is no way, in this small book, to write about all the relationships in a forest landscape, even if we knew them. What we should know is that forests are much more than the trees for which we name them. They are an expression of thousands of interactions, based on millions of years of evolution and adaptation. All creating order and balance amongst species.

History of a Landscape: in brief

Touted for their rich and unique natural history, the Great Smoky Mountains have an equally rich and unique cultural history. Those two histories are closely intertwined. The area that is now Great Smoky Mountains National Park, because of its near vertical landscape, was not considered prime location for large Native American villages or towns. It was, for thousands of years, used primarily as an area for hunting and gathering for the Mississippian and Cherokee towns that surrounded it.

The influx of Europeans into North American, and their need for land, began the push west in search of new land. In the late 1700's the Great Smokies must have been just as imposing a site as they are

today, and more so, as there were no roads to lead them through the wilderness of valleys and high peaks. European settlement happened relatively slowly, beginning in the fertile, lower valleys and moving higher in elevation when the need for land justified the poor farming that was to be had on the steep slopes. Farms were small and subsistent in nature. Timber was cleared to make room for a few acres of crops and pasture. The giant old growth trees, being too large and unwieldy to use, were left alone or sometimes girdled and left to die where they stood. The rich and unique culture, created by the many nationalities, particularly Scots and Irish, that settled the Great Smokies is still celebrated in the national park.

Farming was the main industry in the Great Smokies until the big lumber companies noticed the wealth of available timber. Large-scale logging operations begin around the turn of the century and continued well into the 1940's. Logging methods became quite sophisticated, with rail lines in most major watersheds. Skidders, splash dams, and other mechanical methods were used to bring out the timber. A high percentage of Great Smoky Mountains National Park was clear-cut by the time the National Park Movement was successful in having the Great Smoky Mountains designated as a national park in 1934. Logging continued, even after the creation of the national park, as logging companies used the last of their timber rights. Today we can still find reminders of the logging days as we drive and hike on old railroad beds, find cables and old machinery, and see the forests that regenerated after the last cross-cut saw was stilled. The fact that we have a national park is a testament to the vision of a few people who could see past the deforested mountainsides to the magnificent forest that would eventually return.

Logging certainly had an impact on the landscape and forest health. It will take centuries to regain the deep, rich soils that washed away from the bare mountainsides and we will never experience the old growth forests the way they once were. But that isn't all due to logging. Our forests have forever been changed by some of the smallest things in nature. One, the chestnut blight, a non-native fungus that found it's way to North America early in the 20th century, caused the demise of the chestnut tree, one of the most common trees and most important food producers in the Southern Appalachian landscape. Soon after, the balsam wooly adelgid, a non-native insect that attacks and kills mature Fraser fir trees, began its deadly romp through the high elevation Fraser fir forests, leaving behind white, standing "ghost trees" in its wake.

Today we have new threats. The Dogwood Anthracnose kills dogwoods in the moist forest interiors and the newest non-native threat, the hemlock wooly adelgid, kills Eastern hemlocks within just a few years. Add to these problems those caused by air pollution, acid deposition, and other non-native pests, and it is clear that our forests are in peril. The National Park Service is aware of these problems and is working hard to mitigate as many as possible. Their efforts to combat the hemlock wooly adelgid seem Herculean. Spraying soap sprays, injecting pesticides, rearing tiny beetles that feed on the adelgid, conducting research, and educating the public; all in an effort to thwart this tiny pest. They know the value of Eastern hemlock trees to so many forest ecosystems and species of animals. They also know that our children have the right to see these magnificent trees, uncompromised and in their full glory.

How to use this document

This document is organized into an introductory section that discusses much of the why and wherefore of forest types, their distribution, and organization. It then describes each forest type in turn, giving details about their dominant tree species, associated vegetation, animal species, and status. All plant names include the most common name used in park literature as well as the Latin name for the plant. All Latin names are found in ***Vascular Plants of the Great Smoky Mountains*** which follows

taxonomic nomeclature in ***A Synonomized Checklist of the Vascular Flora of the United States, Canada, and Greenland*** by J.T. Kartesz.

Unfortunately, it is impossible to list all species in each forest or even to give very detailed accounts of each forest type. There are so many interesting things to know about these forest systems, their inhabitants, and the relationships between them that we cannot include in this text. If, however, you are interested in more information than has been provided, please locate one of the many resource listed in the bibliography. They have been provided so that you can become more intimate with our forests and their natural history.

Forest Profiles

Mixed Hardwood Forest

Distribution: Widespread through out the park below 4,000' elevation.

Mixed hardwood forests are common throughout Great Smoky Mountains National Park. They are found in valleys and on slopes up to 4,000' elevation. These forests can be found in mesic to more xeric conditions with the forest composition changing to accommodate the different moisture levels. More exposed sites will contain oaks and hickories that are adapted to dry conditions while maples, yellow poplar, and American beech dominate mesic sites. White oak (*Quercus alba*) is a common component to most sites. In areas that have had recent human impact, particularly old agricultural fields, yellow poplar (*Liriodendron tulipifera*) is often dominant.

To recognize mixed hardwood forests look for a diversity of tree species with a high percentage of oak and hickory. The sub-canopy is well developed and includes several magnolia (*Magnolia spp.*), flowering dogwood (*Cornus florida*), sourwood (*Oxydendrum arboreum*), striped maple (*Acer pensylvanicum*), and others. The shrub layer is also prominent with a number of Viburnum, mountain laurel (*Kalmia latifolia*), and blueberry (*Vaccinium spp.*). Since this forest type is common throughout much of eastern North America it looks, to many, like the "regular forest" they have back home.

Dominant Tree Species
As the name implies, no species of tree is truly dominant in mixed hardwood forests. They are composed of a variety of tree species, some more common in one location and some more common in others. Representative tree species include: white oak (*Quercus alba*), northern red oak (*Quercus rubra*), black oak (*Quercus velutina*), chestnut oak (*Quercus prinus*), mockernut hickory (*Carya tomentosa*), pignut hickory (*Carya glabra*), flowering dogwood (*Cornus florida*), American beech (*Fagus grandifolia*), white ash (*Fraxinus americana var americana*), Fraser magnolia (*Magnolia fraseri*), cucumber tree (*Magnolia accuminata*), yellow poplar (*Lireodendron tulipifera*), black gum (*Nyssa sylvatica*), and American holly (*Ilex opaca*). Although these are the more common species, many others may be present.

Associate Vegetation
The shrub layer in mixed hardwood forests varies in density. Rosebay rhododendron (*Rhododendron maximum)* and mountain laurel (*Kalmia latifolia*) occur but species such as witch hazel (*Hamamelis virginiana*), maple leaf viburnum (*Viburnum acerifolium*), various blueberries (*Vaccinium spp.),* and flame azalea (*Rhododendron calendulaceum*) are more common. Vines and herbaceous species include catbriar (*Smilax spp.*) dutchman's pipe (*Aristolochia macrophylla*), lion's paw (*Prenanthes altissima*), Solomon's seal (*Polygonatum biflorum*), and Christmas fern (*Polystichum acrostichoides*).

Related Animal Species
Black bear, grey squirrel, eastern chipmunk, raccoon, opossum, white-footed mouse, and a number of other mammals find food and shelter in this forest type. Hard mast producing trees such as the oaks and hickories provide a great deal of high-energy foods for these mammals as well as turkey, blue jay, and numerous woodpeckers. Black and white warbler, northern parula warbler, red-eyed vireo, scarlet

tanager, and many other songbirds can be found here. Mixed hardwood forests are also habitat for a number of reptiles and amphibians; including black rat snake, northern ring-necked snake, northern copperhead, eastern box turtle, northern slimy salamander, red spotted newt, and Blue Ridge two-lined salamander.

Status
Mixed hardwood forests are stable communities that exist throughout the park and, with some differences in vegetation, throughout eastern North America. Since the introduction of the chestnut blight and the death of chestnuts, which were a cornerstone species in mixed hardwood forests, the forests are slowly reconfiguring themselves. Stands of chestnut on drier slopes have been replaced by oaks and hickories and on more mesic sites by red maple and yellow poplar. These forests are still in transition.

Places to see a mixed hardwood forest:
Mixed hardwood forests are common throughout the park. Fine examples can be found in Sugarland valley and along most trails that are found below 4,000' elevation.

Pine-Oak Forest

Distribution: below 4,000' elevation on exposed and south facing slopes throughout the park

Xeric pine-oak forests are found on most low to mid elevation dry ridges and south and west facing slopes throughout the park. They are a marked contrast to the rich, green cove hardwood forests found in protected valleys and on north facing slopes. Species in pine-oak forests are adapted to thin, xeric soils, higher temperatures, and fire. Fire is an important component to these systems as it returns important minerals and nutrients to already poor soils by rendering dead and decaying wood to ashes. Some species, such as the table mountain pine, are dependent upon fire for successful reproduction, as it opens their cones so that seeds may be released just as the soil has been giving a jolt of minerals. Often after a fire, the forest will recover quickly, greening-up as many of the ericaceous plants re-sprout with a growth spurt.

Pine-oak forests are often tangles of mountain laurel, blueberry, and huckleberry with an open canopy of pines and oaks. These forests are hotter and drier than any other in the park and in the afternoon have a hot, arid, bright climate that contrasts greatly with other forests. Often pine-oak forests contain rock outcroppings that provide habitat for plants of primary succession and plants that are adapted to the extreme dry conditions of these microsites. Many of these plants, such as Carolina hemlock (*Tsuga caroliniana*) are endemic to these southern Appalachian locations. Rock outcroppings also provide habitat for one of our most beautiful snakes, the timber rattlesnake. There they sun themselves and may use the crevices as hibernacula for over-wintering.

Dominant Tree Species
The canopy of a pine-oak forest consists primarily of xerophytic pines and oaks. The tree composition of a pine-oak forest depends largely on its exposure and the amount of moisture in the soil. Pines dominate the canopy on exposed, xeric ridges while oaks and hickories become more common in

moister soils. Scarlet (*Quercus coccinea*), southern red (*Quercus falcata*), chestnut (*Quercus montana*), and black (*Quercus velutina*) are the principle oaks of these areas. Pines include shortleaf (*Pinus echinata*) and Virginia (*Pinus virginiana*) in the lower elevations with pitch (*Pinus rigida*) and table mountain pine (*Pinus pungens*) as the elevation increases. Black gum (*Nyssa sylvatica*) and sourwood (*Oxydendrum arboreum*) are often present in the sub-canopy.

Associate Vegetation
The shrub layer in pine-oak forest is dominated by members of the heath family. Mountain laurel (*Kalamia latifolia*) is common, along with several blueberries (*Vaccinium spp.)* and huckleberries (*Gaylussacia spp.)*.. The herbaceous layer is not well developed, however trailing arbutus (*Epigaea repens*) and wintergreen (*Gaultheria procumbens*) are common. The most common herb, often found in large colonies, is galax (*Galax urceolata*) which can be recognized as much by its skunk-like odor as its glossy round leaves. The skunk odor comes, not from the lovely white flowers, but from a mycorrhizal fungi that is associated with galax's root system. Many xerophyllic wildflowers can be found in the pine-oak forest including a number of orchid species. Pink lady slipper (*Cypripedium acaule*) can be quite common, along with yellow fringed orchid (*Plantanthera ciliaris*) and an observant hiker may spot green adder's mouth orchid (*Malaxis unifolia*) or perhaps large whorled pogonia (*Isotria verticillata*). Also look for yellow star grass (*Hypoxis hirsute*), hawkweed (*Hieracium spp.*) and golden aster (*Heterotheca spp.*).

Related Animal Species
Acorns from oaks and seeds from pines are important food sources for many species. Grey squirrel, black bear, and chipmunk all feed on the acorns along with turkey, numerous woodpeckers, and ruffed grouse. Other common birds include pine warbler, blue jay, white breasted nuthatch, summer tanager, and black and white warbler. The soft mast provided by numerous blueberry and huckleberry shrubs attract black bear to these forests in late summer. There they will often lie on the ground, pulling branches of shrubs to them to strip the fruit. Timber rattlesnake, black racer, several species of skink, and fence swift are some of the reptiles that prefer this warmer, dry habitat.

Status
Pine-oak forests are relatively stable communities with few threats. This may change if sudden oak death, a disease affecting oak trees in California and recently documented in the southeast, appears in the park. Although often thought of as a threat, the mass death of pines, caused by southern pine beetle after drought or other environmental stresses, is a part of the natural cycle of a pine forest. The largest threat to many of these communities is suppression of fire. Many species are dependent upon fire to return nutrients, tied up in dead wood, to the nutrient-poor soil and some, such as table mountain pine, are dependent upon fire for successful reproduction. The National Park Service conducts controlled burns each year in many of these communities in order to provide these forests with this elemental part of their existence.

Places to see a pine-oak forest:
Many of the park's boundary trails, such as Little Greenbriar and Roundtop wind through pine-oak forests. Other trails encounter pine-oak forest as they crest ridges and curve around to the south side of mountains.

Eastern Hemlock Forest

Distribution: Found throughout the national park in a variety of terrain
Elevation: 1,500 – 4,500'

An Eastern hemlock forest is always a great place to be on a hot day in the Smokies. These towering conifers provide splendid shade beneath their thick branches and a springy mat of needles upon which to sit. The 100 foot tall trees with their massive trunks give the forest a cathedral effect. The understory of Eastern hemlock forests may be thick with rhododendron or may contain very few plants at all.

Eastern hemlock forests are found throughout the park in a variety of terrain. They are distinguished from cove-hardwood forests or mixed hardwood forests by the dominance of Eastern hemlocks in the canopy. Some may be on upper slopes or ridges, others on flats and still others along stream corridors. These stream-side forests provide an important service to thousands of miles of small streams by shading them from the sun and creating a cooler climate. Cooler water contains more dissolved oxygen and more dissolved oxygen means higher aquatic species diversity.

Eastern hemlock forests provide habitat for a variety of animals, particularly birds which find the shelter provided by the thick evergreen needles attractive. Red squirrels are often found feeding on their cones.

Dominant Tree Species
Eastern Hemlock (*Tsuga canadensis*) may occupy more than 70 – 80 percent of the canopy at higher elevations and, because of the large size of hemlocks, can dominate the canopy, even when they comprise only 20 – 30 percent of the forest species. Associate tree species will include silverbell (*Halesia tetraptera*), Fraser magnolia (*Magnolia fraseri*), yellow birch (*Betula alleghaniensis*). They may also include an understory of American holly (*Ilex opaca*), black birch (*Betula lenta*), striped maple (*Acer pensylvanicum*), and other small tree species.

Associate Vegetation
Steep slopes may have a shrub layer that is dominated by rosebay rhododendron (*Rhododendron maximum*) or, at higher elevations, Catawba rhododendron (*Rhododendron catawbiense*). Doghobble (*Leucothoë fontanesiana)* is a frequent shrub with wild hydrangea (*Hydrangea arborescens ssp. arborescens)* and mountain laurel (*Kalmia latifolia*) showing up occasionally. The herb layer is poor to nonexistent, due to the low amounts of sunlight, highly acidic soils, and low soil moisture levels. The few successful herbs include intermediate wood fern (*Dryopteris intermedia*), partridge berry (*Mitchella repens*), and rattlesnake plaintain (*Goodyera repens*). Herb coverage is dependent upon the amount of rhododendron coverage and, at times may be replaced by a sterile layer of hemlock and rhododendron leaves.

Related Animal Species
The thick canopy of the Eastern hemlock forest is used by many species such as the black-throated green warbler, blue-headed vireo, yellow-bellied sapsucker, great-horned owl and red squirrel. The value of their protective branch as a roosting location, particularly in winter, is also recognized. Many of the species that inhabit the mixed hardwood forests and cove hardwood forests can be found here.

Status
Until recently the Eastern hemlock forests in Great Smoky Mountains National Park were considered a stable plant community. They occupy many types of terrain and range throughout the National Park.

Over the past few years, however, the hemlock wooly adelgid (*Adelges tsugae*) has entered the park and may cause large-scale changes in all Eastern hemlock forests. The hemlock wooly adelgid is a non-native insect that attacks the new growth on hemlock trees, killing it and thereby eventually killing the tree. Already 85 percent of the hemlock trees in Shannanondoa National Park have been decimated by the hemlock wooly adelgid and trees in GSMNP are showing negative effects. The National Park and other concerned people are working towards a solution to the problem, however, despite the effort, large scale mortality is expected throughout the park. The death of the hemlock forests will have numerous negative effects on wildlife species and stream habitats. Many species use Eastern hemlocks as primary habitat, feed on their seeds, and find shelter in their branches. Many streams are boarded by Eastern hemlock forests and those forests provide important shade for the streams and their inhabitants. The loss of hemlocks will certainly mean that average stream temperatures will increase, sunlight may increase algae populations, and overall the quality of stream habitat and therefore the number of stream organisms will decrease. We must do all we can to support the conservation efforts for Eastern hemlocks.

Places to see an eastern hemlock forest:

Porters Creek Trail
Abram's Creek Campground

Cove Hardwood Forest

Distribution: Park-wide in protected valley's and northern facing slopes
Elevation: 1,000 – 4,500'

You know when you enter a cove hardwood forest. The moist, fecund smell of growing plants and rich earth combined with the trickle of small streams, the beer-beer-beer-beeee of the black-throated blue warbler and a profound feeling that this must be forest primeval are indicators that you have arrived in a very special place. You see before you a forest that has survived ice ages, climate shifts, and logging and still it can be counted among the most beautiful forests in the world. The open, gallery-like appearance of a cove hardwood forest, with its high leafy canopy that soars over a rich carpet of herbaceous plants is the forest of our dreams.

Cove hardwood forests are found in protected valleys and on northern facing slopes from the lowest elevations of the park to around 4,500' elevation. The deep, moist soils found in these areas support a luxuriant carpet of herbaceous plants and trees of prodigious size. The shrub layer is rather poorly developed, emphasizing tree height and the splendor of the green ground cover. Trunks of the canopy trees reach 3 – 4 feet in diameter, with old growth trees reaching 6 or more feet in diameter. Most tree canopies do not begin until they reach 75 – 100 feet above the forest floor with the tops of trees reaching 100 – 150 feet. The herbaceous layer is the richest of all forest types in the Southern Appalachians. Over 100 species can be found in the dense layer that, in some sites, covers as much as 80% of the forest floor with a amazing green blanket of herbs and ferns.

Cove hardwood forests are found only in the Southern Appalachian Mountains and support many rare and/or endemic species. A quick look will often turn up a Jordan's salamander, a large red-cheeked salamander that is endemic to Great Smoky Mountains National Park. Ginseng, yellowwood, and other uncommon plants may be glimpsed as you walk through the forest and, if quiet, you may hear the song of the cerulean warbler.

To really appreciate the grandeur of a cove hardwood forest you must visit one that has reached the status of "old growth". There tulip trees and yellow buckeye reach tremendous girth and height. The many micro-climates created by the pit and mound topography give the forest floor vegetative diversity and the herbaceous layer is completely developed. Here you will find a forest in change as you view light gaps created by fallen trees and the new trees striving to take their places. Nurse logs nourish wildflowers and trees alike and tall snags stand like sentinels. Here is truly "forest primeval".

Dominant Tree Species

Eastern hemlock (*Tsuga canadensis*), silverbell (*Halesia tetraptera*), yellow buckeye (*Aesculus flava*), basswood (*Tilia Americana var. heterophylla*), suger maple (*Acer saccharum*), yellow birch (*Betula alleghaniensis*) are most common while tuliptree (*Liriodendron tulipifera*) and American beech (*Fagus grandifolia*) are important in some stands. Together, these 8 trees make up 80 – 90% of the canopy of cove hardwood forests.

Associate Vegetation

Cove Hardwood forests contain a great diversity of plant species, both woody and herbaceous. Many other woody plants occur amongst the 8 dominant species. These include: red maple (*Acer rubrum*), black cherry (*Prunus serotina*), Fraser's magnolia (*Magnolia fraseri),* white ash (*Fraxinus americana var. americana*), and shagbark hickory (*Carya ovata*). Sub-canopy species include stripped maple (*Acer pensylvanicum*), Fraser magnolia (*Magnolia fraseri*), and ironwood (*Carpinus caroliniana*). The shrub layer is poorly developed but may contain rosebay rhododendron (*Rhododendron maximum*), doghobble (*Leucothoë editorum*), strawberry bush (*Euonymus americanus*), and wild hydrangea (*Hydrangea arborescens*).

Some of the most abundant herbaceous species are: white snakeroot (*Eupatorium rugosum*), black cohosh (*Cimicifuga racemosa*), jewelweed (*Impatiens pallida*), Canadian violet (*Viola canadensis*), southern lady fern (*Athryium filix-femina var. asplenoides*), plantain-leaved sedge (*Carex plantaginea*) and intermediate wood fern (*Dryopteris intermedia*). This short list does not do justice to the magnificent diversity of herbaceous plants and the splendid wildflower display they produce each spring. The herbaceous layer is itself stratified with prostrate plants growing under spreading ferns and herbs. Throughout the year the dominant species change as early spring ephemerals go dormant, allowing summer species to dominate the herb layer.

Related Animal Species

The high productivity of cove hardwood forests offers much to many. Certainly our largest omnivore, the black bear, finds a great deal of food in the form of grubs, roots, and fruit in this forest. The moist conditions and plenty of cover provide habitat for many species of salamanders, including Jordan's, southern Appalachian, imitator, and blue ridge two-lined. The whistle of eastern chipmunks and chirr of red squirrels are constant companions in the cove hardwood forest as is the song of the black-throated green warbler, black-throated blue warbler, veery, ovenbird, junco, and many other species of bird.

Status

Found in the rich, moist soils of protected valleys and slopes, cove hardwood forests are found only in the Southern Appalachian Mountains. Although relatively secure many remaining forests have been affected by logging and will take centuries to regain their previous glory. Today, a significant threat to the cove hardwood forest comes from the affects of the hemlock wooly adelgid on Eastern hemlock trees, which are prominent in these systems. Loss of hemlocks will change the forest make-up to a degree that we don't know at this time.

Places to see a cove hardwood forest

Cove Hardwood Nature Trail - Chimneys Picnic Area
This lovely loop trail leads you through a magnificent cove hardwood forest that includes a bit of old growth at the top.

Albright Grove – A beautiful old growth cove hardwood forest. It is worth the 7-mile round-trip hike.

Quiet Walkways along Newfound Gap Road – Many of the quiet walkways and pull-offs midway from to Newfound Gap from both the North Carolina and Tennessee sides are in cove hardwood forests.

Northern Hardwood Forest

Distribution: 4,000 to 5,500' elevation throughout Great Smoky Mountains National Park
Elevation:

If you are from New England you will recognize something familiar in the northern hardwood forest. These forests are remnants of a time when glaciers forced northern forests south. As the climate warmed and glaciers receded, forests types shifted to our present day configuration. However the northern hardwood forests, similar to those in New Hampshire and New York, found refuge on the cool upper slopes of our southern Appalachian mountains. Today northern hardwood forests are found in the higher elevations of the national park. They are composed chiefly of deciduous trees and give us some of the best fall color in the mountains.

Drive Newfound Gap Road, and just above Alum Cave trailhead you will notice a subtle shift in forest type as the rich cove hardwood forests give way to northern hardwoods containing much more yellow birch (*Betula alleghaniensis*), northern red oak (*Quercus rubra*), sugar maple (*Acer saccharum*), and American beech (*Fagus grandifolia*). Fire cherry (*Prunus pennsylvanica*), with its long, toothed leaves and reddish bark will begin to make an appearance and the white flowered rosebay rhododendron (*Rhododendron maximum*) will give way to magenta Catawba rhododendron (*R. catawbiense*). A stop at one of the many pull-offs will give you a chance to enjoy the magnificent displays of green-headed coneflower (*Rudbeckia lanciniata*) and red bee balm (*Monarda didyma*) in late summer. Looking up slope you will even see tall, conical red spruce (*Picea rubens*) at the ecotone where northern hardwoods and red spruce begin to merge. An early spring walk gives the chance to enjoy birdsong and perhaps even the drumming of a ruffed grouse while one in late October will find you in the midst of a magnificent fall color.

Dominant Tree Species

Dominant trees in the northern hardwood forest include red oak (*Quercus rubrus*), yellow buckeye (*Aesculus flava*), yellow birch (Betula alleghaniensis), sugar maple (*Acer saccharum*), and American beech (*Fagus grandifolia*). Northern red oak (*Quercus rubra*) is often more dominant on drier, south facing slopes while yellow buckeye (*Aesculus flava*), yellow birch, and American beech become more dominant on mesic north facing slopes. Other trees, such as chestnut oak (*Quercus montana*), red maple (*Acer rubrum var. rubrum*), and Eastern hemlock (*Tsuga canadensis*) are found lower numbers. Red spruce (*Picea rubens*) will grade into the northern hardwood forests along transition zones.

Associate Vegetation
The shrub layer may include rosebay rhododendron (*Rhododendron maximum*) in the lower elevations of the northern hardwood forest range, and Catawba rhododendron (*Rhododendron catawbiense*) and mountain laurel (Kalmia latifolia) in the higher, more exposed areas. Mountain holly (*Ilex montana*), common elderberry (*Sambucus canadensis*) and witch hobble (*Viburnum lantanoides*) can be found in lower elevations and mountain ash (*Sorbus americana*) will grade into higher forests.

The herbaceous layer of the northern hardwood forest is well developed and includes numerous wildflowers such as umbrella leaf (*Diphylleia cymosa*), fringed phacelia (*Phaceila fimbriata*), spring beauty (*Claytonia caroliniana*), turks-cap lily (*Lilium superbum*), green headed coneflower (*Rudbeckia laciniata*), and beebalm (*Monarda didyma*). Ferns such as intermediate wood fern (*Dryopteris intermedia*), southern lady fern (*Athyrium filix-femina var. asplenoides*), and of course Christmas fern (*Polystichum acrostichoides*), the most common fern in the park, are found throughout.

Related Animal Species
A number of wildlife species find habitat in the northern hardwood forest. Black bear, red squirrel, red-backed voles, and bobcat make their home here. There are also several endemic races of species that are found in the high mountains of the southern Appalachians. They include the Appalachian cottontail, the newly named Appalachian yellow-bellied sapsucker, the saw-whet owl, and the Carolina northern flying squirrel. Jordan's salamander, a salamander found only within the boarders of Great Smoky Mountains National Park, enhabits the northern hardwood forest along with the pygmy salamander. Bird species include blue-headed vireo, black-throated blue warbler, and dark-eyed junco.

Status
The northern hardwood forest flanks much of the upper slopes of Great Smoky Mountains National Park. Its frequency and physiognomy give it a degree of stability however there are threats to individual species that inhabit the forest. American beech trees are threatened by beech bark disease. The Carolina northern flying squirrel and saw-whet owl are of concern due to their limited numbers. Air pollution in the form of acid rain and ozone damage plants and acidify soil and streams.

Places to see a northern hardwood forest:

Excellent examples of northern hardwood forests can be seen along Newfound Gap Road above Alum Cave Trailhead and along Heintooga Road. Almost any hike at elevations between 4,000 and 5,500' will take you to northern hardwood forests.

Beech Forest (northern hardwood forest sub-type)

Distribution: 4,000 to 5,500' elevation throughout Great Smoky Mountains National Park

Beech forests are sub-types of northern hardwood forests that occur primarily above 4,500' elevation. When they occur on broad ridges they are often called "beech orchards" for the orchard-like affect of the open forest and stunted trees. When occurring in concave topography they are called "beech gaps". Often beech gaps occur as small pockets in spruce-fir forests with distinct and abrupt transitions from one to the other. Beech forests are found where harsh conditions limit the growth of other tree species. Their locations on high ridges and gaps mean that they get more than there share of wind and cold

temperatures, giving them their stunted appearance. Often their wind-sculpted canopy resembles the canopy of maritime forests along coastal islands.

Beech forests are very distinct plant communities. The uniformity of the trees, lack of a shrub layer, and low herbaceous layer give them the look of an orchard. The short, stunted trees with grey shaggy lichens on their trunks seem almost elfin in appearance. They often have spectacular displays of spring beauties (*Houstonia caroliniana*) and trout lily (*Erythronium americanum*) in the mid-spring and bright "gardens" of green-headed coneflower (Rudbeckia laciniata) , turks cap lily (*lilium superbum*), and red bee balm (*Monarda didyma*) in late summer.

Dominant Tree Species
Gray beech forests are, as the name indicates, dominated by American beech (*Fagus grandifolia*) which, in the high elevations, attains a very different look and form than its lower elevation counterpart. The high elevation beech is a small tree, seldom exceeding 15 inches in diameter and with crowns from 12 to 20 feet high. This stunted growth is due to the extreme conditions; high winds, heavy icing, and low temperatures that American beech withstand in their high elevation forests. They also have a thick layer of lichen that coat their trunks, hiding the characteristic smooth beech bark. While American beech dominates these forests, two trees of the cove hardwood and northern hardwood forests, yellow birch (*Betula alleghaniensis*) and yellow buckeye (*Aesculus flava*) are also important in the canopy. The sparse sub-canopy may contain mountain maple (*Acer spicatum*), striped maple (*Acer pensylvanicum*), and serviceberry (*Amelanchier laevis*).

Associate Vegetation
The gray beech forests of north facing slopes has a limited shrub layer that contains some wild hydrangea (*Hydrangea arborescens ssp. arborescens*), alternate leaf dogwood (*Cornus alternifolia*), and witch hobble (*Viburnum lantanoides).* The herbaceous layer is similar to that of the upper cove hardwood forest but with a light coverage of sedges nearly always present. Common high elevation plants include Rugel's ragwort (*Rugelia nudicaulis*) which is endemic to Great Smoky Mountains National Park, green headed coneflower (*Rudbeckia lanciniata*), rosy twisted stalk (*Streptopus roseus*), and others.

South facing gray beech forests lack a sub-canopy and shrub layer. Their herbaceous layer is dominated by sedges which can cover 80 – 90% of the forest floor. With the sedges will occur large populations of spring beauty (*Claytonia caroliniana*), trout lily (*Erythronium americanum*), filmy angelica (*Angelica triquinata*), goldenrod (*Solidago spp.).*

Related Animal Species
Most of the wildlife species associated with the typic northern hardwood forest are also found in the gray beech forests.

Status
Gray beech forests, particularly the type found on south facing slopes, are the most limited forest types in Great Smoky Mountains National Park. They are hardy forests, able to withstand harsh weather conditions but are affected by two non-native pests. One, beech bark disease, causes mortality in beech trees. The wild boar (Sus scrofa) is a problem because its rooting can destroy much of the herbaceous vegetation in the gray beech forest.

Places to see a gray beech forest:

A walk along the Appalachian trail will take you through several beech gaps. There is one fine example located approximately a half mile north of Indian Gap on the Appalachian Trail. This beech gap forest is surrounded by a hog exclosure to protect it from the damage that wild hogs can inflict. Therefore it is in pristine condition and in late spring offers a lovely display of spring beauties and trout lilies.
Grey beech forests can also be viewed around the outer edges of some high elevation balds.

Spruce - Fir Forest

Distribution: Elevations above 4,500'. The crest of the Smokies.

The conifer dominated spruce-fir forest seems a world away from the deciduous forests that blanket the majority of our mountains. Two tree species, red spruce (*Picea rubens*) and Fraser fir (*Abies fraseri*) make up the majority of the forest canopy which shelters a small number of shrub and herbaceous species. Their dark trunks rise high above the mossy forest floor, blocking sunlight and keeping the forest floor in a state of perpetual twilight. Footsteps are muffled by a thick layer of needles, which, due to low temperatures and acidic conditions, take years to decompose. Any plant living below theses evergreens must be tolerant of shade and acidic soils. Stepping into one of these dark, mountain-top woodlands on a day when the clouds swirl and race through the trees and the only sound is that of a winter wren's long, tinkling call is an experience that the first time visitor never forgets.

The Southern Appalachian spruce-fir forest, a relict of the Pleistocene era ice ages, is, due to the current warm climate, confined to mountain-tops in southwestern Virginia, eastern Tennessee, and western North Carolina. It is very similar to the boreal conifer forest of New England and Canada, although the Fraser fir is endemic to the Southern Appalachians.

Spruce-fir forest is the least abundant forest community in the Southern Appalachians. They are separated into disjunct patches that are thought of as high elevation "habitat islands". Because of their limited habitat area these spruce-fir islands are of concern to conservationists. Small size and limited location often means that species populations on these mountain-tops are small and more vulnerable to extinction. The overall range of the spruce-fir forest community has been reduced by fifty percent, due to logging and related impacts. The balsam wooly adelgid, a non-native insect that attacks Fraser fir trees has resulted in a 45 – 90 percent mortality rate of the Fraser fir. Although most spruce-fir forests are now protected and managed by the National Park Service and U.S. Forest Service the outlook for their future health is not positive.

Dominant Tree Species

Spruce-Fir forests do not have a great diversity of tree species. The species that exist in these high elevation forests must be able to endure colder temperatures, short growing seasons, and heavy snow and ice. The two dominant species are, as the forest name implies, red spruce (*Picea rubens*) and Fraser fir (*Abies fraseri*). These two conifers compose the great majority of trees and most often the entire forest canopy. In the lower elevations (4,600' – 5,500'),a few hearty species such as yellow birch (*Betula allegheniensis*), mountain maple (*Acer spicatum*), American beech (*Fagus grandifolia*), fire cherry (*Prunus pennsylvanica*), and yellow buckeye (*Aesculus flava*) are found in association with

red spruce and Fraser fir. Increases in elevation decrease the number of deciduous trees until only one, mountain ash (*Sorbus americana*) is left as an associate to Fraser fir on the highest peaks.

Associate Vegetation

The closed canopy of the spruce-fir forest keeps much of the sunlight from reaching the forest floor and therefore reduces the number of species that can survive in those light levels. Although shrub and herbaceous layers of the spruce-fir forest are not diverse, the species that do survive there are often abundant. The shrub layer is generally composed of witch hobble (*Viburnum lantanoides*), mountain cranberry-bush (*Vaccinium erythrocarpum*), red elderberry (*Sambucus racemosa var. pubens*), and young mountain ash and mountain maple. Exposed ridges and rocky outcrops often have an evergreen understory of Catawba rhododendron (*Rhododendron catawbiensis*) and the most exposed areas may give way to shrub dominated heath balds. Often forest light gaps are colonized by tangles of smooth blackberry canes (*Rubus spp.)* The herbaceous layer is strongly dominated by three ferns; intermediate wood fern (*Dryopteris intermedia*), mountain wood fern (*Dryopteris campyloptera*), and southern lady fern (*Athyrim filix-femina. Var. asplenioides*). In addition, most spruce/fir forest have a luxuriant layer of mosses and lichens and shade tolerant wildflowers such as Clinton's lily (*Clintonia borealis*), oxalis (*Oxalis montana*), Rugels ragwort (*Rugelia nudicaulis*), forming a layer beneath the spreading fern fronds.

Forest edges and roadways offer additional sunlight and support several varieties of wildflowers that are uncommon in the depths of a spruce-fir forest. Spectacular displays of green-headed coneflower (*Rudbeckia lanceolata*), turtleheads (*Chelone lyonii*), red beebalm (*Monarda didyma*), along with filmy angelica (*Angelica triquinata*) and several varieties of orchids can be seen blooming along the road to Clingman's Dome.

Related Animal Species

The Spruce-Fir forests of the Smokies are home to a variety of special animals. Some of these, like the Northern Flying Squirrel, Black-capped chickadee, and Northern saw-whet owl are species of the far north that found refuge in this area during the last ice age, remaining in these northern-type forest refuge as the glaciers receded north and the spruce/fir forest retreated to the tops of mountains. Others, like Jordan's salamander, Rugel's ragwort, and the spruce-fir moss spider are endemic to these mountains, having evolved in the cool, dim world of the spruce-fir.

Bird species such as chestnut-sided warbler, veery, junco, golden-crowned kinglet, red-breasted nuthatch, common raven, and winter wren prefer the high elevation forests. Reptiles are few. They are represented by midland brown snake, eastern garter snake, northern ring-necked snake, and timber rattlesnake, few of which reach the highest elevations of pure fir stands. Amphibians include Jordan's, pigmy, ocoee, imitator, southern grey-cheeked, blue ridge spring, and Blue Ridge two-lined salamanders.

Status

Spruce-fir forests are considered one of the most endangered forest ecosystems in the world. Signs of spruce-fir forest's waning heath can be easily seen. The bare, white trunks of Fraser fir trees, long dead from attack by balsam wooly adelgid, rise amongst the red spruce and form stands of "ghost trees" on the high ridges. The loss of the Fraser fir has changed the forest composition causing a decline in other species; for example, oxalis populations have declined by up to 80 percent since the loss of Fraser fir. Although protected and managed by the National Park Service, their small range, exposure to air pollution and non-native pest species such as the balsam wooly adelgid, make the future of southern Appalachian spruce-fir forests uncertain at best.

Places to see a spruce/fir forest:

New Found Gap
Clingmans Dome
Appalachian Trail

Bibligraphy

Braun E. 1950. Deciduous Forests of Eastern North America. The Blackburn Press. New Jersey.

Clebsch E., Busing R. 1989. Secondary Succession, Gap Dynamics, and Community Structure in a Southern Appalachian Cove Forest. Ecology. 70:3: 728 – 635.

Elliott K., Vose J., Swank W., Bolstad P.,1999. Long-term patterns in vegetation-site relationships in a southern Appalachian forest. Journal of the Torrey Botanical Society. 126: 320 – 334.

Evans M., 2005. Ferns of the Smokies. Great Smoky Mountains Association. Gatlinburg.

Forest Encyclopedia Network. The Encyclopedia of Southern Appalachian Forest Ecosystems. Rauscher, H. Forest Encyclopedia Homepage. < http://www.forestryencyclopedia.net>. Accessed May 2006.

Great Smoky Mountains Natural History Association. Vascular Plants of the Great Smoky Mountains: A Checklist for the Vascular Plants of Great Smoky Mountains National Park.

Golden M. 1980. An Integrated Multivariate Analysis of Forest Communities of the Central Great Smoky Mountains. The American Midland Naturalist. 106: 37 – 53.

Oosting H., Billings W. 1951. A Comparison of Virgin Spruce-Fir Forest in the Northern and Southern Appalachian System. Ecology. 32:1:84 – 103.

Schafale M., Weakley A. 1990 Classification of the Natural Communities of North Carolina; Third Approximation. North Carolina Natural Heritage Program.

Shanks R. 1954. Climates of the Great Smoky Mountains. Ecology. 35:3: 354 – 361.

Tilley S., Huheey J. 2001. Reptiles and Amphibians of the Smokies. Great Smoky Mountains Natural History Association. Gatlinburg.

Whittaker R.H. 1966. Forest Dimensions and Production in the Great Smoky Mountains. Ecology. 47:1: 103 – 120.

Whittaker R.H. 1956. Vegetation of the Great Smoky Mountains. Ecological Monographs. 26:1:1 – 80.

Wilson J., Agnew A., Sykes M. 2004. Ecology or mythology? Are Whittaker's "gradient analysis" curves relilable evidence of continuity in vegetation? Preslia, Praha. 76: 245 – 253.

Woods F., Shanks R. 1959. Natural Replacement of Chestnut by Other Species in the Great Smoky Mountains National Park. Ecology. 40:3: 349 – 360.

Yarnasaki M., DeGraaf R., Lanier J. Wildlife Habitat Associations in Eastern Hemlock – Birds, Smaller Mammals and Forest Carnivores. In: Proceedings: Symposium on Sustainable Management of Hemlock Ecosystems in Eastern North America. 135 – 143.