

# Tennessee's High-elevation Ecosystems

## What are High-elevation Ecosystems?

Between the heights of 4,400 feet in the Great Smoky Mountains National Park in Tennessee and 6,684 feet on top of Mount Mitchell in North Carolina's Black Mountain Range lie the unique and often mysterious high-elevation ecosystems of the Southern Appalachians. The Appalachians are considered one of the oldest mountain ranges in existence. Long ago these mountains soared higher than the Rocky Mountains and Swiss Alps, but over the eons they have gradually worn down to their present heights by natural erosion processes. The high slopes, domes, peaks, and ridges of eastern Tennessee, western North Carolina and southwestern Virginia possess a climate similar to Canada's and are home to islandlike patches of spruce-fir forests, rocky cliffs, and mountain balds.

The Southern Appalachians were not covered with ice during the full glacial period of the last Ice Age nor were they ever flooded by oceans. While evolution was slowed or halted in the frozen parts of the world for thousands of years, plants and animals of this region continued to thrive and evolve. Geological stability combined with diverse climate and topography have made the Southern Appalachians one of the most biologically diverse regions in the world. This diversity is reflected in our high-elevation ecosystems.

Southern Appalachian spruce-fir forests typically are found above 5,500 feet, grading into stands of northern hardwoods at lower elevations. Accompanying the red spruce and Fraser fir at their lower limits are scattered yellow birch, American mountain ash, sugar maple, mountain maple, and a variety of shrubs and herbaceous plants. The shallow rocky soils are acidic and generally covered with a thick organic layer. Biologically unique, these forests provide us with a living museum from another time. Thousands of years ago



spruce-fir forests covered the surrounding valleys and mountain peaks of the Southern Appalachians. As the glaciers retreated and the climate warmed, the spruce-fir forests withdrew to the tops of our highest mountains and spread northward. During this progression the high-elevation species of the Southern Appalachians are believed to have contributed to the evolution of the widespread boreal forests of the Northern United States and Canada. Thus, the only true relict ecosystem of the spruce-fir forest lies in the Southern Appalachians, where it has persisted continuously over the last 18,000 years. Today these southern mountaintop forests are characterized by a number of plants and animals found nowhere else on earth, along with other species that are common today only in sub-Arctic regions.

High-elevation cliffs and rocky outcrops can be found on many ridges and valleys in the Southern Appalachians. These ecosystems

were molded over time by the harsh conditions of exposure to extreme cold and winds of up to 130 miles an hour. Although these rocky areas seem bare at first glance, they actually provide habitat for several relict tundra-like species that have adapted to the extreme climate.

Grassy balds share the ridge tops and "saddles" of the highest peaks in the Southern Appalachians. These unique ecosystems appear to be large grassy meadows in the forest, with azaleas, rhododendrons, and other shrubs scattered across them. Their location and unusual plant life prove that many of the balds are quite old. Generations of mountain residents have pondered how and why these high-elevation meadows came to be. Our Southern peaks are hospitable for tree growth, so how is it that these areas are not forested.

Some believe the balds have pre-Cherokee origins. Perhaps early Native Americans cleared the balds to

improve hunting or to look for approaching enemies. Some scientists hypothesize that a catastrophic fire long ago played a part in the creation of mountain balds. Early mountain grazers, such as elk and bison, may have kept these bald areas clear of trees.

### **Why are High-elevation Ecosystems Important?**

The high-elevation ecosystems of the Southern Appalachians are biologically unique and geographically restricted and support an abundance of rare plants and animals. Because of their antiquity and ancestral affinity to the northern coniferous forests, they are a wealth of diversity and a tremendous and largely unrealized scientific resource. Also, because they sit at the headwaters of mountain streams, they are extremely valuable for watershed protection. Their canopy and understory vegetation slows down and filters rainwater. Thus, they greatly benefit the water quality of these streams and enhance downstream fisheries.

High-elevation ecosystems are aesthetically important to recreational users. Hundreds of thousands of visitors flock to the Southern Appalachian Mountains each year for backpacking, nature walks, camping, picnicking, photography, and driving for pleasure. Mount Mitchell State Park in North Carolina, the Blue Ridge Parkway and the Great Smoky Mountains National Park in North Carolina and Tennessee, and Mount Rogers National Recreation Area in Virginia provide opportunities for people from all over the country to escape to the peace and beauty of mountains that are still wild and unspoiled.

### **Diversity of Life in High-elevation Ecosystems**

High-elevation ecosystems provide habitats for an impressive diversity of wildlife. Many mammals visit these mountaintops, and some make their homes there year-round. Big brown bats, red squirrels, eastern chipmunks, woodland jumping mice, gray foxes, spotted skunks, bobcats, and black bears have all been spotted

feeding and taking shelter in high-elevation ecosystems. The diversity of bird species here thrills visiting birders, who may be lucky enough to glimpse the rare American peregrine falcon, red crossbill, red-breasted nuthatch, snow bunting, raven, black-throated green warbler, black-throated blue warbler, Canada warbler, and magnolia warbler.

Many of our high-elevation species are rare, some so rare that they are nearing extinction and are federally listed as endangered or threatened. The Southern spruce-fir forests provide the only remaining habitat for the endangered Carolina northern flying squirrel and spruce-fir moss spider. These forests support rare plants and unusual amphibians, such as imitator and pigmy salamanders. The elusive saw-whet owl depends on these forests, along with rare mammals, such as the masked, long-tailed, and pygmy shrews. Unfortunately, even the Fraser fir itself is in significant decline and is considered a species of federal concern.

Grassy balds are home to the rare Gray's lily and purple gentian and the endangered Roan Mountain bluet and spreading avens. Greenland sandwort, bent avens, and Arctic bent grass can also be found in these mountaintop grasslands. High-elevation cliffs and rocky outcrops can provide suitable habitat for the endangered peregrine falcon, spreading avens, and rock gnome lichen, and the threatened Heller's blazing star and Blue Ridge goldenrod.

### **Threats to High-elevation Ecosystems**

Although high-elevation ecosystems appear rugged, they are extremely fragile. A number of factors threaten these valuable ecosystems, including atmospheric pollution, climate change, disease, insect damage, and other factors not yet fully understood. Spruce-fir forests have been reduced by as much as 50 percent, primarily as a result of logging followed by severe fires in the earlier part of this century. These forests are now being decimated by an exotic species—the balsam wooly adelgid. The

balsam wooly adelgid, native to Europe, was first identified in Maine in 1908. It probably arrived prior to 1900 on imported nursery stock. This tiny sucking insect feeds on the inner bark of true fir trees, causing their death within 2 to 7 years after infestation. This wingless pest is dispersed by the wind and probably came to the Southern Appalachians as early as the 1940s. Mount Mitchell in North Carolina was found to be infested in 1957, and surrounding Southern Appalachian spruce-fir forests were found to be infested by 1963. The balsam wooly adelgid has since been found in every Fraser fir stand. Unfortunately, Fraser fir is the most sensitive fir species to balsam wooly adelgid infestation. The spread of the adelgid throughout Southern spruce-fir forest communities has resulted in the massive mortality of mature Fraser firs. Losing one of the dominant canopy species has, in turn, caused major changes in temperature and moisture levels in the understory, threatening numerous other species that rely on the cool, moist conditions maintained by the fir. Other nonnative species, such as the European wild boar, also damage high-elevation ecosystems. Boars root and destroy sensitive habitats and the roots of trees and plants. Exotic grasses, like Timothy grass, often choke out native plants.

Because of their severe climate, high mountain ecosystems may be especially prone to air pollution. However, the effects of pollutants are difficult to separate from the effects of other factors, like the balsam wooly adelgid; so, the role that air pollution has played in the reduction of spruce-fir forests is not fully understood.

Regardless of the causes of Fraser fir decline, the disappearance of this dominant tree species has adversely affected other members of the ecosystem. For instance, the loss of Fraser firs, having created openings in the canopy, has exposed the red spruce trees to high winds, causing the trees to fall. As these forests disappear the moisture available to neighboring cliffs and mountain balds decreases.

High-elevation ecosystems face other threats as well. The heavy human traffic through these beautiful areas exposes the rare species that live here to many dangers. Cliff edges, rock outcrops, moss-covered boulders, and grassy balds are particularly attractive to hikers, rock climbers, and picnickers. As a result, trampling has become a severe threat to many rare plant and small animal populations, like salamanders and spiders. Thousands of people visit these mountains year after year and are not aware of the sensitive nature of the landscape, where soils are so shallow one stomp can crush a rare plant. A moss mat on a single boulder, easily destroyed by trampling, may provide one of the last refuges for a rare species like the spruce-fir moss spider. Picking and digging up wildflowers creates another substantial threat; a rare population of 100 plants could easily be wiped out by flower collection. The careless or deliberate cutting of live trees or saplings for firewood and the creation of illegal campsites further threaten these pressured ecosystems.

### **What's Being Done?**

Most of the high-elevation ecosystems of the Southern Appalachians are owned or managed by federal or state governments. In addition to the acreage contained within the Great Smoky Mountains National Park, Mount Mitchell State Park, the Balsam Mountains, and Mount Rogers National Recreation Area, about 10,000 acres of the crest of the Roan Mountain massif are owned and managed by the U.S. Forest Service. There are 7,000 acres in the Pisgah National Forest, and 3,000 acres are part of the Cherokee National Forest. The public ownership of these lands helps to ensure their existence for our use and enjoyment and for that of future generations.

Efforts are underway to protect and restore high-elevation ecosystems. Signs and barriers warning of sensitive habitats have been posted at many rocky outcrops to help visitors treat ecosystems responsibly. Goats have been used to graze and maintain grassy balds. Researchers are attempting to develop methods to

control the balsam wooly adelgid. However, the remoteness of these areas and the difficulty in treating the trees, while not impacting other species, presents significant logistical challenges. It is hoped that a breakthrough treatment will be developed that is inexpensive and easily applied so that the balsam wooly adelgid will one day cease to be a pest in these ecosystems. Also, conservation organizations and the scientific community continue to research the effects of atmospheric deposition and other factors harming the health of our high-elevation ecosystems, hoping that management solutions to these perplexing problems will be discovered.

### **Seeing is Believing!**

Tennessee has many trails, parks, and natural areas where you can get a close-up view of wild plants and creatures and their habitats. Using the supplemental *Tennessee Wildlife Viewing Guide*, locate and visit a high-elevation ecosystem, but keep in mind the uniqueness and fragility of what you are enjoying!

### **You Can Help!**

*Remember, although high-elevation ecosystems appear rugged, they are quite fragile. Always stay on trails and boardwalks to avoid trampling or damaging vegetation. Avoid climbing on rocky outcrops and moss-covered boulders; these habitats and the species they support are extremely fragile and easily destroyed. Avoid picking wildflowers in sensitive ecosystems. Camp only at authorized sites and comply with the regulations for the use of these sites. Read and pay attention to signs warning of sensitive habitats. Continue to learn and then educate others about high-elevation ecosystems. Take pride in and enjoy our high-elevation ecosystems!*





# Spruce-fir Moss Spider

(*Microhexura motivaga*)

## You Can Help!

*Tell a friend about the spruce-fir moss spider. Protect high-elevation ecosystems by preventing air pollution. Stay on trails when hiking in high mountains to avoid trampling unique habitats. Avoid climbing on vegetated rocky outcrops and boulders. Take pride in Tennessee's wildlife!*

## Status

The spruce-fir moss spider was listed as endangered on February 6, 1995.

## Description

The spruce-fir moss spider is the world's smallest tarantula. Adults are about the size of a BB, measuring only 3 to 5 millimeters across. These tiny spiders range in color from light brown to yellow or reddish brown.

## Habitat

The spruce-fir moss spider depends on Southern Appalachian spruce-fir forests. There are only three small populations of this high-elevation species—two in North Carolina and one in Sevier County, Tennessee. The spider's habitat is made up of damp, well-shaded moss mats that grow on top of rocks and boulders. The spider builds tube-shaped webs between the moss mats and the rock surface. The mats must have just the right amount of moisture; too much water could drown the tiny spider and too little could cause it to dry out.

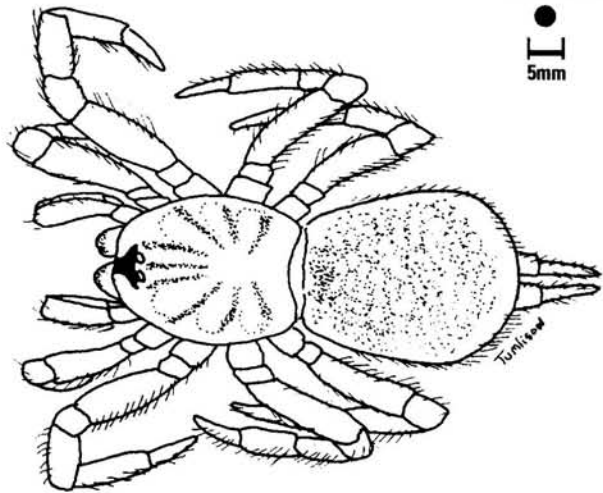
## Life History

Little is known about the secretive spruce-fir moss spider; its breeding habits and life span are a mystery.

## Role in the Ecosystem

The diet of the spruce-fir moss spider isn't known, but springtails (tiny creatures that share the spider's habitat) may be a likely food source. Many types of spiders are known to be important food sources for birds, lizards, wasps, and other animals. Spider silk is important to many bird species for nest building. Did you know that spider silk is very elastic, and twice as strong as steel! Researchers are currently investigating tarantula venom for medicinal uses. The venom may

Actual Size



provide a treatment for Alzheimer's and Parkinson's diseases and may help prevent brain damage in stroke patients.

## Threats

The spruce-fir moss spider is threatened by the loss of its spruce-fir forest ecosystem. The death and thinning of these high-elevation forests result in increased temperatures and decreased moisture, which cause the spider's moss mat habitat to dry out. As the moss mats dry out, so do the spiders. Spruce-fir forests have declined because of an exotic insect (the balsam wooly adelgid), and air pollution seems to have played a part in the loss of these unique forests.

## Recovery

Efforts are underway to establish a captive-breeding program for the spruce-fir moss spider. Studies of the spider's life history, habitat requirements, and threats to its spruce-fir ecosystem will continue and may provide further insight into recovery actions.

# Rock Gnome Lichen

(*Gymnoderma lineare*)

## You Can Help!

*Tell a friend about the rock gnome lichen. Protect high-elevation ecosystems by supporting local, regional, and national clean air standards. Stay on trails when hiking in high mountains to avoid trampling unique habitats. Avoid climbing on vegetated rocky outcrops and boulders. Pay attention to signs that prevent access to sensitive mountain habitats. Take pride in Tennessee's wild lichens!*



## Status

The rock gnome lichen was listed as endangered on January 18, 1995.

## Description

The rock gnome lichen grows in dense colonies of narrow, straplike structures. Each strap is only about 2 centimeters long, and the tip of each strap curls upward. The lichen is blue-gray above and shiny white below. A lichen is a combination of a fungus and an algae. Together they form a new organism, supporting each other in environments where they could not survive alone; this process is called mutualism. The algae photosynthesizes and obtains energy from the sun, while the fungus provides structure for the organism.

## Habitat

The rock gnome lichen is found in the Southern Appalachian Mountains of North Carolina and Tennessee. It occurs only in areas with high humidity, either in high areas where it is frequently bathed in fog or in deep river gorges at lower elevations. The rock gnome lichen has very specific requirements for light and moisture. It grows on bare rock faces or cliffs, where water seeps from above the forests on very wet days. Most populations are above 5,000 feet in elevation. Currently there are 32 remaining populations of the rock gnome lichen. Only seven of these are larger than 2 square meters, and most of the populations are less than 1 square meter in size.

## Life History

Lichens spread when small fragments are broken off and become attached to other patches of rock. New colonies form from these small fragments.

## Role in the Ecosystem

Lichens do not need an organic food source; they require only light, air, and a few minerals. The rock gnome lichen gets some minerals from its rocky cliff home, but most minerals reach the lichen through the air and

in rainfall. Lichens are often the first organisms to grow on bare rocky areas. Their presence slowly changes the surface environment, gradually creating new habitat for mosses, ferns, and other plants. Because lichens quickly soak up substances in rainwater, they are very sensitive to airborne pollution. The presence or absence of lichens can indicate the quality of the air in a particular area; where lichens thrive, the air is good for people and creatures to breathe.

## Threats

The rock gnome lichen has declined for several reasons. Its rocky habitat makes it susceptible to trampling by outdoor enthusiasts who are unaware of its presence. Hikers, climbers, and sightseers crush the lichen as they climb around on its rocky home. The nearby spruce-fir forests have declined because of the balsam wooly adelgid, an exotic insect, and airborne pollution. As these forests disappear, the moisture available to the lichen decreases, and the lichen dries out. Because lichens are sensitive to airborne pollution, it is suspected that further decline has been caused by poor air quality and polluted fog.

## Recovery

Nearly all of the remaining populations of the rock gnome lichen are on public land. The U.S. Forest Service and the National Park Service are working with the U.S. Fish and Wildlife Service to protect the species from trampling and collection. Efforts are also underway to monitor the effects of air pollution on this rare lichen. The North Carolina and Tennessee Natural Heritage Programs, the North Carolina Plant Conservation Program, and The Nature Conservancy also work to protect the rock gnome lichen.

# Carolina Northern Flying Squirrel

(*Glaucomys sabrinus coloratus*)

## You Can Help!

*Tell a friend about the Carolina northern flying squirrel. Protect high-elevation ecosystems by supporting local, regional, and national clean air standards. Take a break from your car; walk to the store, post office, or school. Protect air quality by conserving electricity; turn off the lights. Take pride in Tennessee's wildlife!*



## Status

The Carolina northern flying squirrel was listed as endangered on July 1, 1985.

## Description

The Carolina northern flying squirrel is a small gray mammal with a whitish underside. Adults weigh about 3 to 5 ounces, or about as much as a banana, and grow to a length of about 10 to 12 inches. The squirrel has large eyes, silky fur, and a long, flattened tail. Folds of skin stretch between the squirrel's wrists and ankles. To travel, it leaps, and these folds of skin stretch out to help the squirrel "parachute," or glide, from tree to tree. The Carolina northern flying squirrel is nocturnal—active at night.

## Habitat

Carolina northern flying squirrels depend on high-elevation forests in the Southern Appalachian Mountains of North Carolina and Tennessee. They occur in the transition, or overlap, area between the high peaks, domes, and ridges of the spruce-fir forests and the northern hardwood forests, which grow at lower elevations. Hollow trees in the oak-dominated hardwood forests provide nesting cavities for the squirrels. Both the spruce-fir and hardwood forests are used in their search for food. They prefer older forests, with widely spaced tall trees that are easy to glide between.

## Life History

Carolina northern flying squirrels nest in tree cavities, which they line with lichens, moss, and finely chewed bark. Two to six young are produced each spring. Little is known about this rare squirrel's life, but it is believed that they live in small family groups of adults and young squirrels. They remain active throughout the winter.



## Role in the Ecosystem

Carolina northern flying squirrels eat lichens and fungi, seeds, buds, fruit, and insects. These squirrels may help maintain the forests by dispersing nitrogen-fixing bacteria and fungal spores that are needed by trees for proper growth.

## Threats

The Carolina northern flying squirrel is adapted to the cold, harsh conditions of the Southern Appalachian high-elevation ecosystems. It is thought that populations of the squirrel have been shrinking due to natural conditions since the last Ice Age. The species is now isolated in small, restricted areas, and the decline of Southern Appalachian spruce-fir forests, due to exotic insect invasions and other factors, threatens the squirrel with extinction. Habitat decline has also caused increased competition for nesting habitat between the Carolina northern flying squirrel and its lower-elevation counterpart, the southern flying squirrel.

## Recovery

The primary recovery goal for the Carolina northern flying squirrel is to learn more about this elusive species' habitat requirements, diet, and relations with other species. Once these squirrels are better understood, more effective management decisions can be made. Efforts are being made to protect the areas where the squirrel is known to live.