

by Jim Wheeler

In 1850, close to 2,000,000 acres of old-growth coast redwood forest canopy mantled the coastal mountains of California. Today, less than four percent of that canopy remains.

Old-growth (ancient) redwood forests are not simply stands of big, beautiful trees — they are relatively stable, complex ecosystems dominated by large conifer trees hundreds of years old. Some redwoods grow to be two thousand years old and more than 360 feet tall.

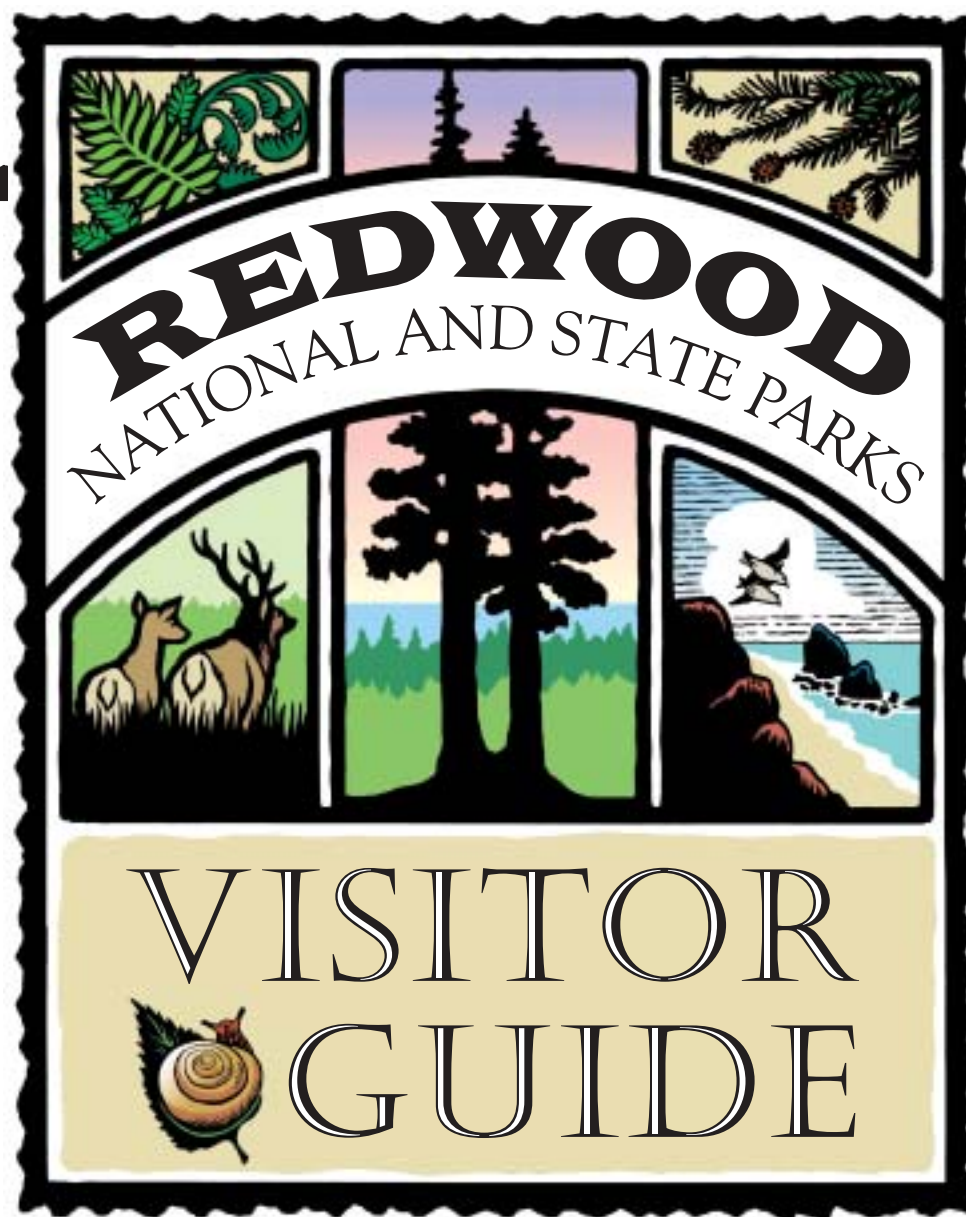
Large trees are often widely spaced and highly individual, shaped over centuries by windstorms, drought, and fire. These four ingredients: age, wind, drought, and fire combine to produce the gnarliest forest canopy in the world, one that supports entire ecosystems in the sky.

**A**GE. The remnant old-growth redwood forests that exist in the parks today are among the oldest forests on Earth. Redwoods reach the upper canopy within 200-400 years, enabling them to develop individual characteristics that create some of the most complex tree crowns ever found.

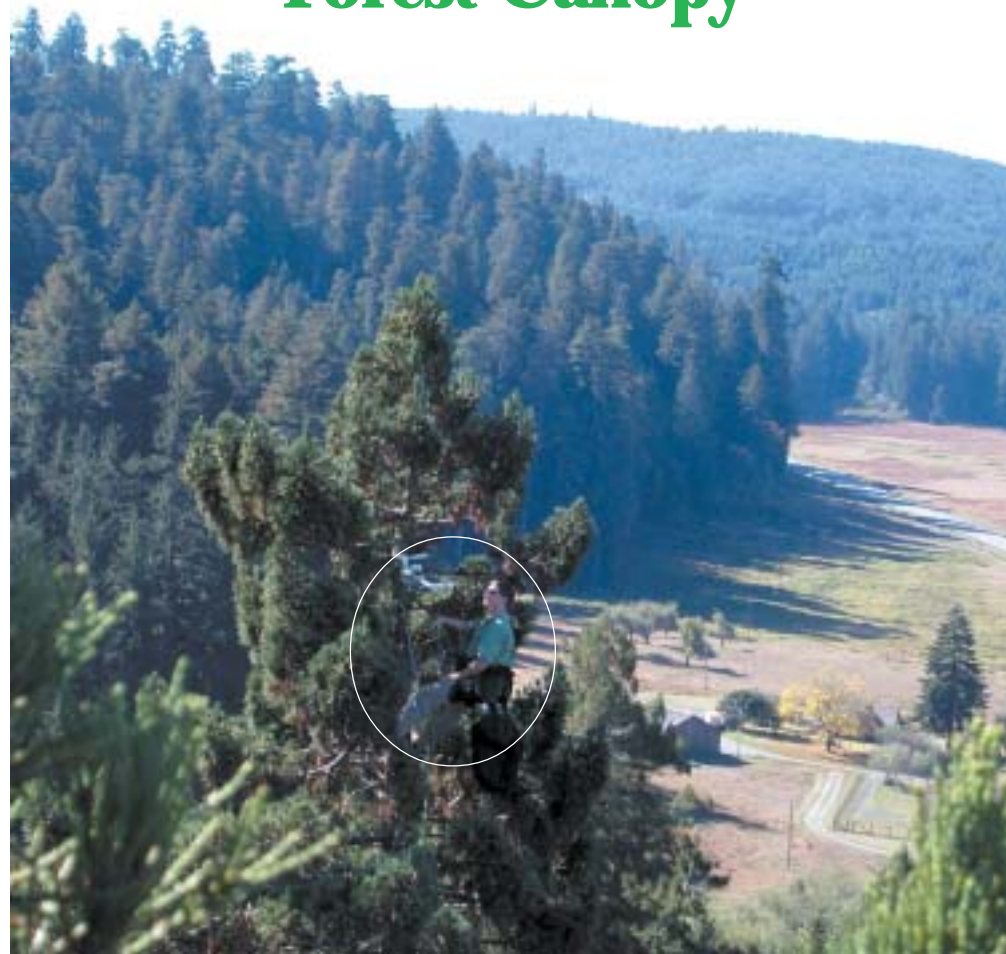
Above 150 feet, primeval redwood trees develop massive limbs that can support tree-sized trunks growing on them. Multiple trunks growing in one treetop appears as a rounded silhouette from a distance. Previously logged, even aged younger forests contain conifers less than 150 feet tall that all have pointed tops with young branches.

With time, deep organic soils accumulate on large limbs. Thirteen different species of plants, shrubs, and trees, most of which normally grow on the forest floor, grow in these soils. The soil mats provide homes to thousands of invertebrates, mollusks, earthworms, and salamanders.

**W**IND. During gale-force winds, branches or trunks from adjacent trees knock against each other causing wounds or breakage. The injuries within the crowns allow light to pass through the canopy, which results in new sprouts on trunks and branches. As a result of longevity and responses to wind damage, many ancient redwoods have extremely intricate crowns consisting of



## Recipe for a Healthy Forest Canopy



The scientific exploration of old-growth redwood forest canopies began in 1996 when Dr. Steve Sillett, seen here at 320 feet up in one treetop of Prairie Creek Redwoods State Park, began teaching at Humboldt State University. His research team discovered entire ecosystems in the redwood canopy. Yet the canopy and the forest floor have much in common!

Photo by George Koch

multiple tree trunks, each supporting its own system of branches — *and all within the crown of a single tree.*

Called reiterations, these trunks emerge from huge lateral branches that often rival the diameter of the largest trees in other forests. One tree on Redwood Creek has 148 reiterations beginning about 150 feet above ground. From a distance, its broad crown can easily be mistaken for several large trees growing close together.

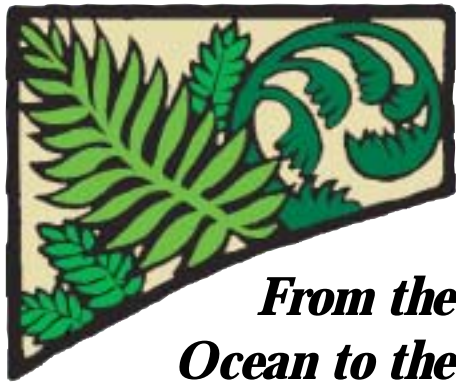
**D**ROUGHT. Although annual rainfall can exceed 80 inches, from late May to November redwoods experience the dry season. During drought years, some treetops die back. From across a river or a prairie, look at the old redwoods — many display dead tops. Yet they are not dead. During wet years a typical redwood will resprout several new trunks from just below the top, developing a series of new leaders heading for the sky.

Amazingly, reiterated trunks develop root systems in accumulated soils at their base, aiding the whole tree in water transport to its highest reaches. During the dry season, the lush, multi-faceted canopy soaks up moisture from coastal fog, and fog can account for up to one-third of the water a giant needs annually.

**F**IRE. Fire reaches the canopy in two ways: Lightning strikes an individual tree, or low-intensity fires on the ground slowly smolder up the bark and into the canopy. Either way, fire generates new sprouts — expanding and strengthening canopy layers.

**A**N UNSEEN WORLD RE-VEALED. Until recently, this unseen world in the old-growth canopy remained a mystery. Few of us will ever see the gnarly treetop world of marbled murrelets, red tree voles, and northern spotted owls.

Today, scientists use modern archery and rope-based climbing technology to uncover entire ecosystems within the forest canopy — revealing age, wind, drought, and fire as the mixture that makes a canopy complex. Exposing this unseen world is redefining the significance of remaining old-growth forests.



## From the Ocean to the Redwood Canopy

Pacific northwest old-growth forest canopies provide a home to one of the rarest and most unique seabirds in the world, the marbled murrelet. No one knew where the robin-sized bird nested until 1973, when the first nest was discovered on a large branch high in a colossal redwood tree — making murrelets the only non-tropical seabird to nest in trees.

Most of the murrelets left in California nest in Redwood National and State Parks. They are a “poster bird” for ancient trees: The murrelets’ presence indicates a healthy forest. Today the forest is fragmented, a patchwork of old- and second-growth areas. With fewer places on high to land and raise a chick, these spotty-colored birds are federally-listed as threatened.

Marbled murrelet adult on nest and a chick. Photos by Ron LaValley



As you stand — back arched, neck extended — trying to look into the round-top canopies at Prairie Creek Redwoods State Park, listen. At dusk or dawn, you may hear the sharp *keer* of a murrelet overhead. One adult is returning to the nest with food. If you are incredibly lucky, you will see the poster bird for a healthy forest speed through the sky like a bullet.

### Help Save the Marbled Murrelet!

Predators such as ravens, crows, and jays are eating murrelet eggs and young birds. While looking for strewn garbage, they find the murrelet’s nest instead. Please attend to all food items at your camp and on the trails. Please don’t feed any wildlife.

**Don’t make a good bird go bad!**

# Canopy

The unseen world of the redwood canopy holds just as much life as the forest floor! Birds, berries, salamanders, conifers, lichens, bugs, and much more make up an entire ecosystem in the sky. Some species live their whole life in this lush climate-controlled refuge.

## The Tie That Binds

By Debbie Savage



fly agaric  
*Amanita muscaria*

The first thing I noticed when I moved to coastal California is the rain — up to 100 inches a year. I soon learned that the rain transforms every level of the forest into a colorful array of fungi in all sizes, shapes, and textures, revealing a hidden world with names like fly agaric, witch’s butter, and turkey tail. Intrigued, I followed a trail of fungus from the forest floor to the canopy, searching for a connection.

By maintaining a cool, moist environment, the canopy provides ideal habitat for over 300 species of fungus. Fungus is a collection of filaments or threads that may extend for several miles beneath the surface. These threads (hyphae) produce two types of fruiting bodies, mushrooms above ground and truffles underground. Most fungi obtain nutrients by breaking down leaves, cones, and other forest litter constantly shed from the canopy.

Some fungi infect young tree roots to form a beneficial structure called mycorrhizae (from the Latin mycor for fungus, rhiza for root). By growing into the roots and extending out into the soil, mycorrhizae increase the tree’s ability to absorb water and elements such as phosphorus, zinc, manganese, and copper. These filaments also produce antibiotics to protect the roots from disease. In exchange, the fungi receive sugars from the tree’s root system.

Many forest animals rely on fungi in their diet. Chipmunks on the ground and flying squirrels in the canopy dig for truffles. Roosevelt elk, black bears, banana slugs, and millipedes graze on mushrooms. In turn, these animals disperse fungus spores in their fecal pellets, and new fungi grow from the spores.

The more I learned the more I realized that fungi threads bind the old-growth forest community together. It is the thread that connects the canopy to the soil and forms a vast underground transportation system for water and nutrients. Follow that thread the next time you visit and see where it takes you.

**Epiphytes: Plants that grow on plants.**

## Aerial Gardens

By Lynne Mager

If you could take a red carpet ride above the redwood forest and look into the candelabra canopy, you would notice tremendous fern mats attached to the branches and tree trunks. Hovering above, you might glimpse the circle of life existing inside and outside these hanging gardens.

Tree-sized limbs radiating from the 1,000 year-old redwood stem provide a lofty perch for branches, bark, and needles falling through the canopy. A whole flora of fungus rots the debris into “canopy soils” — a rich humus similar to what you’d like to achieve in backyard compost. Have you looked in your soil lately? Like any healthy garden, these soil mats fill with earthworms, bugs, and crustaceans.

Researchers who climb into the canopy were 200 feet up a tree when they saw “in driving rain, on the side of the bark, this earthworm cruising at high speed . . . just going for it.” From the forest floor to the canopy, some critters find their way to aerial gardens

that offer protection from terrestrial predators.

During the rainy season, the deep soils soak up water and become a haven for epiphytes: plants that grow on plants. One researcher found over 1,000 pounds of leather fern, the most common aerial garden plant, growing in one soil mat.

Imagine flying your red carpet 100 feet down into the canopy. Here chickadees, ruby-crowned kinglets, and brown creepers gorge on red and black huckleberry thickets. An array of shrubbery normally found on the ground can also grow 300 feet above, roots firmly embedded in rich soil mats. Even western hemlock and Sitka spruce trees sprout.

When the rainy season subsides, the gardens in the sky survive on water dripping through the soil mats, a continuous sprinkler system. What’s in



270 feet high

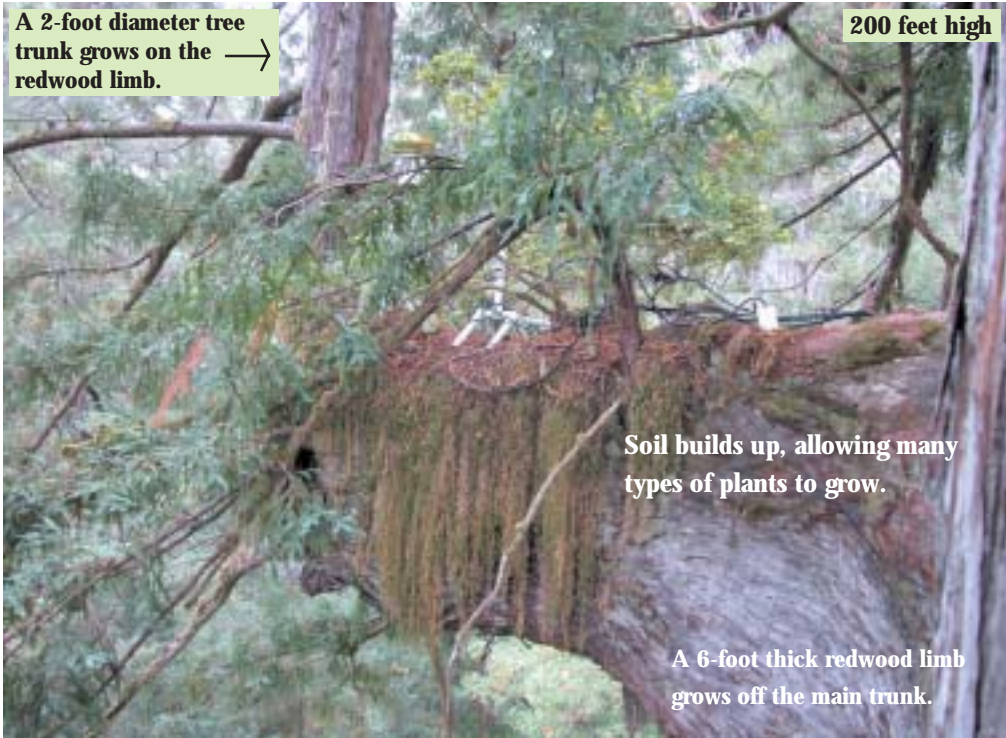
**A bouquet of leather ferns, the most common aerial garden plant, dangles from the crotch of a tree.**

Photo by Thomas Dunklin

your backyard treetops? In the redwood canopy, “plants growing on plants” provide food, water, and shelter for an exquisite ecosystem that’s home to salamanders, birds, and mammals, some of which live their entire lives among the misty hanging gardens.

# Discovering the Unseen World

A 2-foot diameter tree trunk grows on the → redwood limb.



200 feet high

Soil builds up, allowing many types of plants to grow.

A 6-foot thick redwood limb grows off the main trunk.



300 feet high

Top. To gain access to the canopy, Dr. Sillett's team shoots rubber-tipped arrows from a powerful compound bow over sturdy branches up to 290 feet above ground. Arborist-style rope techniques allow movement within the crown, including traversing between tall trees. (Research in Redwood National and State Parks is done by permit only.)

When mapping the crown, the team estimates the wood volume and bark surface area of the main trunk, reiterated trunks, and limbs. Eventually they will be able to estimate the mass and surface area of each tree's leaves.

## Monitoring the microclimate of a treetop ecosystem

Right. Canopy researchers have installed solar-powered sensor arrays that monitor microclimatic conditions in the crown; find out the amount of water stored in canopy soils; and determine how much water is transported through the trees' trunk, reiterated trunks, and limbs. The results will inform the world about how much habitat big canopy provides for a myriad of plants and animals.

Photos by Steve Sillett and George Koch



320 feet high



## A SALAMANDER PARADISE

by Kale Bowling-Schaff

Imagine living your entire life 250 feet above the ground in the redwood canopy, breeding and sleeping in thick, moist soil mats full of tasty insects, well out of reach of ground-dwelling predators. If you were a sticky-toed salamander capable of walking up a tree trunk, this environment might make an ideal home.

The wandering salamander (*Aneides vagrans*) represents just one member of an abundant community of life high above the ground. Previously, scientists observed this three-inch-long salamander in modest numbers camouflaged among rotten logs and rock crevices on the forest floor. Now researchers who climb high in old-growth redwood trees track populations of wandering salamanders that may never come down at all. Thousands of them live in the canopy.

Wandering salamanders thrive in trees more than 400 years old. However, with 96 percent of

the ancient redwood canopy habitat gone, these tiny creatures have resorted to living in debris piles left behind by logging. Due to this adaptation, wandering salamander populations found from Del Norte County south to Sonoma County seem relatively secure. In contrast, amphibians worldwide continue to decline because they cannot adjust to habitat destruction.

Will there be more suitable homes for wandering salamanders and other canopy creatures as protected redwood forests grow back? Only time — and our ability to protect a community in the treetops we seldom see — will tell.



High in the ancient forest canopy a plethora of mosses and lichens attach themselves to branches. Mostly absent from younger forests because they take centuries to grow, lichens fix nitrogen from the atmosphere in their tissues. Eaten by northern flying squirrels or blown to the forest floor, their nutrients leach into the ground and feed all of the forest plants. Ancient trees provide lichens a platform for growth and lichens feed the trees, completing just one cycle that binds the whole redwood ecosystem together.

## Mammals Above!

by Debbie Weist

To see real mammalian canopy action, get out your night vision goggles. After hours, the infamous spotted owl hunts on silent wings. It might find one of its favorite foods, the red tree vole. This diminutive rodent feasts on fir needles, a waxy delicacy few animals can digest. With an abundant supply of needles in the canopy, the voles rarely descend to the forest floor.

The spotted owl also snacks on the northern flying squirrel. These squirrels feast on lichen and subterranean fungi. The squirrels don't really fly; they soar with grace and agility up to 150 feet. In contrast, they crawl awkwardly on the ground, so they spend most of their lives in the treetops as well.

Both the squirrel and vole provide essential nutrients to sustain a healthy old-growth forest by depositing fungal

spores and nitrogen-fixing bacteria with their scat (droppings). The trees rely on these fungi as symbiotic partners in nutrient absorption. From the smallest fungi to the smallest mammals to the tallest trees, a web of interdependence exists in a world outside of our normal scope of vision — the redwood canopy.

**Mammal canopy list:** These critters either live in or forage in and around the redwood canopy:

- hoary bat
- big brown bat
- silver haired bat
- California myotis
- long eared myotis
- long legged myotis
- western red bat
- red tree vole
- chickaree (red squirrel)
- northern flying squirrel
- Townsend chipmunk

